# LETTER

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# Civil conflicts are associated with the global climate

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**It has been proposed that changes in global climate have been responsible for episodes of widespread violence and even the collapse of civilizations[1,2]. Yet previous studies have not shown that violence can be attributed to the global climate, only that random weather events might be correlated with conflict in some cases[3–7]. Here we directly associate planetary-scale climate changes with global patterns of civil conflict by examining the dominant interannual mode of the modern climate[8–10], the El Niño/Southern Oscillation (ENSO). Historians have argued that ENSO may have driven global patterns of civil conflict in the distant past[11–13], a hypothesis that we extend to the modern era and test quantitatively. Using data from 1950 to 2004, we show that the probability of new civil conflicts arising throughout the tropics doubles during El Niño years relative to La Niña years. This result, which indicates that ENSO may have had a role in 21% of all civil conflicts since 1950, is the first demonstration that the stability of modern societies relates strongly to the global climate.**

The idea that the global climate might influence the peacefulness of societies[1,2,11–13] has motivated a growing body of research. However, much of the support for this idea is anecdotal and the two methodologies dominating quantitative work on this problem have yielded inconclusive results[14]. The first of these approaches correlates multi-century trends in regional climate with trends in wars[15,16], but such correlations are weak[16] and gradual social changes over multiple centuries confound results. The second approach avoids confounding trends by correlating random changes in local annual temperature or rainfall with local civil conflicts[3–7], but different statistical assumptions have yielded different results and the notion that random local temperature or rainfall shocks are analogues for global climate changes has been criticized on three grounds: (1) the global climate may affect many interacting environmental variables that influence conflict but are not adequately summarized by averages of local temperature and rainfall; (2) systematic environmental changes that occur on a planetary scale may influence markets, geopolitics or other social systems differently than location-specific weather shocks that are uncorrelated with weather in other locations; (3) predictable changes in climate and unpredictable weather shocks may generate very different social responses, even if they are otherwise identical. To circumvent these concerns, we avoid local proxies for the global climate and instead directly relate global changes in conflict risk to movements in the global climate: specifically, to the rapid annual shifts between El Niño and La Niña phases of ENSO[10].

ENSO may plausibly influence multiple varieties of conflict, such as riots or genocides; however, we restrict this analysis to organized political violence. We examine the Onset and Duration of Intrastate Conflict data set[17], which codes a country as experiencing 'conflict onset' if more than 25 battle-related deaths occur in a new civil dispute between a government and another organized party over a stated political incompatibility (see Supplementary Methods and Supplementary Table 1 for data details). Following common practice[17,18], a dispute is new if it has been at least 2 years since that dispute was last active; however, individual countries may experience conflict onset in sequential years if the government has disputes with different opposition groups. We define annual conflict risk (ACR) in a collection of countries to be the probability that a randomly selected country in the set experiences conflict onset in a given year. Importantly, this ACR measure removes trends due to the growing number of countries[18] (Supplementary Fig. 1).

In an impossible but ideal experiment, we would observe two identical Earths, change the global climate of one and observe whether ACR in the two Earths diverged. In practice, we can approximate this experiment if the one Earth that we do observe randomly shifts back and forth between two different climate states. Such a quasi-experiment is ongoing and is characterized by rapid shifts in the global climate between La Niña and El Niño.

To identify a relation between the global climate and ACR, we compare societies with themselves when they are exposed to different states of the global climate[19]. Heuristically, a society observed during a La Niña is the 'control' for that same society observed during an El Niño 'treatment'. We sharpen this comparison by separating the world into two groups of countries: those whose climate is strongly coupled to ENSO and those weakly affected by ENSO. If climate influences ACR, we expect to observe the larger ENSO signal in the ACR of the former group.

Originating in the tropical Pacific, ENSO influences virtually the entire tropics by radiating waves through the atmosphere, linking climates around the globe through so-called teleconnections[8,9]. During an El Niño event, the continental tropics mostly become warmer and dryer, whereas effects in mid-latitudes are generally smaller and less consistent[9,10]. To capture this, we partition the globe into two groups based on how coupled their climates are to ENSO, separating countries into teleconnected and weakly affected groups (Fig. 1a; see also Methods, Supplementary Figs 2–5 and Methods). We identify teleconnected locations using surface temperature, instead of other variables[8,10], both for theoretical reasons[9] and because it is less variable with broader spatial coverage. We verify that this partition preserves the well-documented structure of ENSO's impact on countries' average surface temperature[9], precipitation[8], and agricultural yields and revenues[20] (Supplementary Table 2 and Supplementary Fig. 6). In the analysis that follows, we base our inferences strictly on correlations over time between ENSO and ACR in the teleconnected group. We analyse ACR in the weakly affected group solely to check that there are no confounding global variables that are correlated with ENSO.

The extremes of the ENSO cycle are distinguished by anomalies of cool (La Niña) or warm (El Niño) sea surface temperature (SST) in the eastern equatorial Pacific[8,10]. We index ENSO by NINO3 (Supplementary Fig. 1), the SST anomaly for the grey region in Fig. 1a. Our results are insensitive to using alternative indices (Supplementary Fig. 7), but detecting ENSO impacts requires that we account for the 'spring barrier'[10] by averaging NINO3 from May to December rather than over the entire calendar year (see Fig. 1b, see also Supplementary Tables 3, 4 and Methods).

We regress the conflict measure ACR on NINO3 for both groups and detect a large and significant increase in ACR associated with warmer NINO3 values only in the teleconnected group (Fig. 2a, b and Supplementary Methods). We build a linear multiple regression

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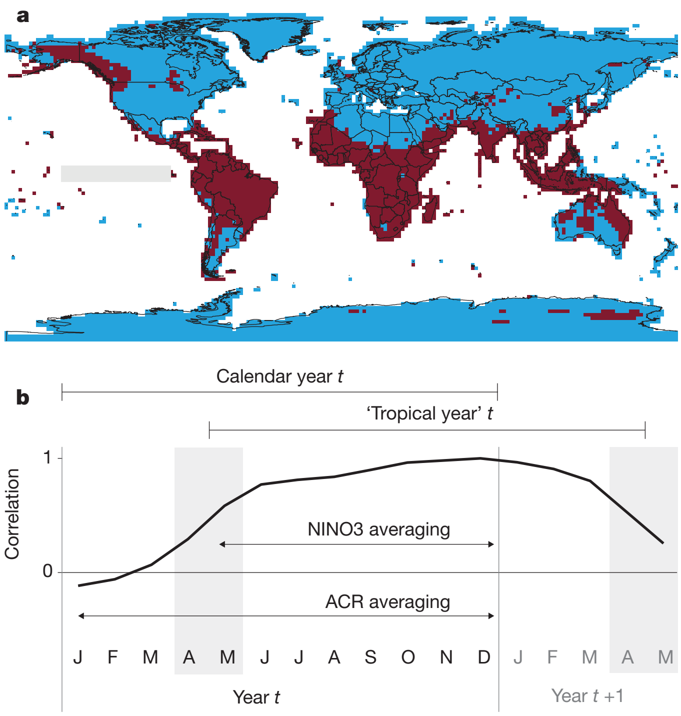


**Figure 1 | ENSO exposure over space and time.** **a**, Red (blue) indicates an ENSO teleconnected (weakly affected) pixel; NINO3 region in grey. **b**, Correlation of monthly NINO3 with NINO3 in December. The natural 'tropical year' begins in May and ends the following April at the 'spring barrier' (grey). To match monthly ENSO data with annual ACR data, an annual ENSO signal is isolated by averaging May–December NINO3.

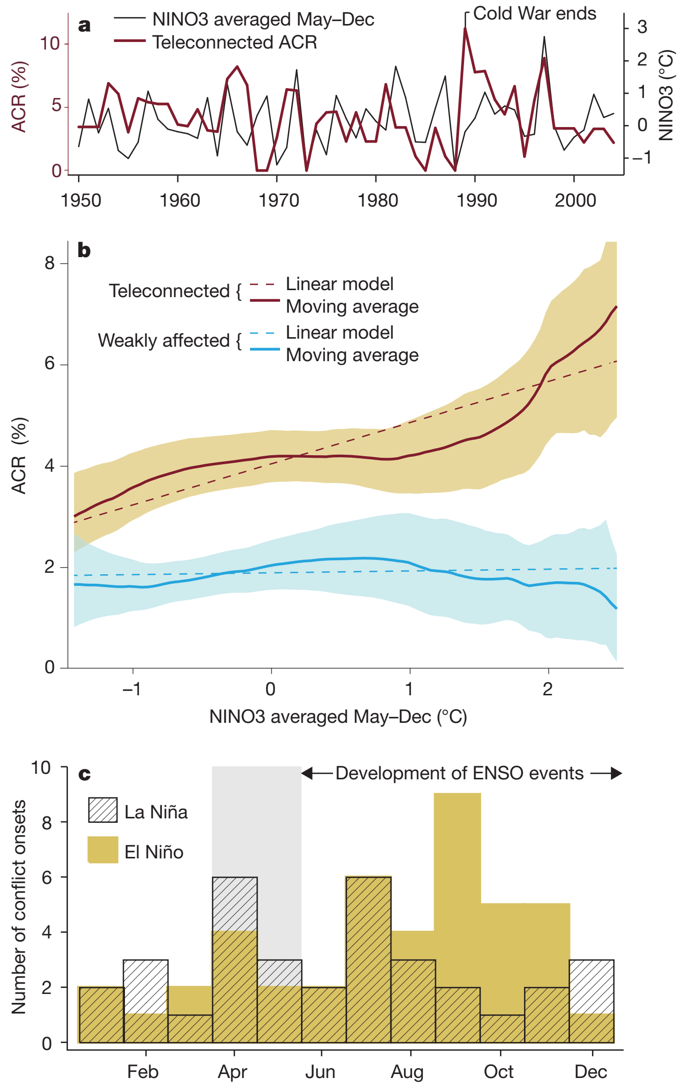


**Figure 2 | Conflict risk associated with ENSO.** **a**, Time series of NINO3 and ACR for the teleconnected group. **b**, Linear and non-parametric fit ($n = 54$, weighted moving average, 90% confidence intervals shaded) of ACR against NINO3. Time trends and mean shift after the end of the Cold War are removed. **c**, Solid (hatched) bars show total monthly conflict onsets in teleconnected countries during one-third of years most El-Niño-like (La-Niña-like). Monthly data are available for only half of the conflicts.

model by including linear time trends and an additive constant to all years after 1989 (inclusive), a common technique[7] to account for mean shifts in ACR after the end of the Cold War (Table 1, rows 1–3). Using a non-parametric regression, we find that ACR in the teleconnected group is most responsive to strong ENSO events and is less affected by smaller deviations from the neutral state (Fig. 2b).

In the teleconnected group, ACR is 3% in the La Niña state and rises to 6% in the El Niño state, whereas ACR in the weakly affected group remains at 2% for all ENSO states (Fig. 2b). This indicates that ENSO may have affected one-fifth (21%) of all civil conflicts during this period (see Methods).

Because ENSO events occur after the April/May 'spring barrier'[10] (Fig. 1b), we expect conflicts triggered by ENSO to occur in the later part of the calendar year. Figure 2c, based on the subset of conflict data available at monthly resolution, shows the within-year distributions of conflict onsets for the teleconnected group in El Niño and La Niña years. The distributions of conflicts are similar early in the year, with substantial differences appearing only after ENSO events are underway.

The correlation we observe between ACR and NINO3 is robust to the battery of statistical models advanced by previous studies[3,5–7] (Supplementary Methods). To ensure the entrance of new countries into the sample do not drive our result, we restrict our sample to the post-colonial period[5] (Table 1, row 4) and estimate a country-level linear probability model[5,7] (row 5). We limit the sample to exclude African countries (row 6) and find that the correlation is not driven exclusively by Africa[3,5,7]. Further, we find that nonlinear probability models (Supplementary Fig. 8), count models (Supplementary Fig. 9) and survival models (Supplementary Table 5) produce indistinguishable results. We find the relationship persists when alternative ENSO indices are used (Supplementary Table 6). We estimate dynamic-panel and first-difference models (Supplementary Table 7) and find no evidence that patterns of serial correlation in either variable drive our results. We expand our sample to include several influential outlying observations (1946, 1948 and 1989, see Supplementary Fig. 10) and find the correlation persists (Supplementary Table 8). We remove country-specific constants and trends from our longitudinal model[7] and find our estimates unchanged (Supplementary Table 9). When we include controls for contemporaneous temperature and precipitation (Supplementary Table 10) or for lagged income, political institutions and population (Supplementary Table 11; see also Supplementary Fig. 11), we continue to find a large and significant influence of ENSO on ACR. We then estimate a model with all of the above controls, as well as controls for gender balance, urbanization, age-structure, income growth, agricultural reliance and cyclone disasters (Supplementary Table 12 and Supplementary Fig. 12) and find that our results persist across African and non-African countries. Finally, using standard definitions[17], we find that neither large (more than 1,000 battle deaths) nor small ($25 < \text{number of battle deaths} < 1{,}000$) conflicts dominate our result (Supplementary Table 13). However, we find that increasing the required peaceful period between conflicts[17] reduces the correlation between ENSO and large conflicts, indicating that many of the large conflicts associated with ENSO are re-occurring conflicts (Supplementary Table 13).

**Table 1 | Regression of ACR on NINO3 averaged May–December 1950–2004**

| Model | Teleconnected (% °C$^{-1}$) | Weakly affected (% °C$^{-1}$) |
|---|---|---|
| (1) Group aggregate | 0.76* (0.39) $n = 54$ | 0.16 (0.31) $n = 54$ |
| (2) Group aggregate Linear trend | 0.85** (0.40) $n = 54$ | 0.06 (0.30) $n = 54$ |
| (3) Group aggregate Linear trend Post-1989 constant | 0.81** (0.32) $n = 54$ | 0.04 (0.31) $n = 54$ |
| (4) Same as (3) 1975–2004 only† | 0.95** (0.34) $n = 29$ | 0.33 (0.45) $n = 29$ |
| (5) Country-level panel Country-specific trends Country-specific constants | 0.89** (0.38) $n = 3{,}978$ | 0.04 (0.29) $n = 3{,}400$ |
| (6) Same as (5) Non-African countries only | 0.84** (0.41) $n = 2{,}084$ | −0.01 (0.29) $n = 3{,}203$ |

Standard errors in parentheses. 1% °C$^{-1}$ means the probability of conflict (ACR) rises 0.01 for each 1 °C in NINO3. 1989 dropped.
* $P < 0.1$; ** $P < 0.05$.
† After 1974, the set of countries in the teleconnected group stabilized at 87–91.

El Niño might accelerate the timing of conflicts that would have occurred later. By examining years following ENSO events, we find suggestive but statistically insignificant evidence that approximately 40% of the conflicts associated with ENSO are displaced in time (Supplementary Table 14).

We evaluate the relative sensitivities of different countries by estimating a separate regression for each country ($i$), decomposing ACR into a baseline component ($\alpha_i$) independent of ENSO and a component ($\beta_i$) that varies linearly with NINO3: $ACR_i(t) = \alpha_i + \beta_i NINO3(t)$ (Supplementary Methods). In the teleconnected group, low-income countries are the most responsive to ENSO (that is, $\beta$ is larger), whereas similarly low income countries in the weakly affected group do not respond significantly to ENSO (Fig. 3). Note that the dependence of baseline ACR $\alpha$ on income is statistically indistinguishable between the two groups.

Although we observe that the ACR of low-income countries is most strongly associated with ENSO, we cannot determine if (1) they respond strongly because they are low-income, (2) they are low income because they are sensitive to ENSO, or (3) they are sensitive to ENSO and low income for some third unobservable reason. Hypothesis (1) is supported by evidence that poor countries lack the resources to mitigate the effects of environmental changes[1,21,22]. However, hypothesis (2) is plausible because ENSO existed before the invention of agriculture[10] and conflict induces economic underperformance[3,18].

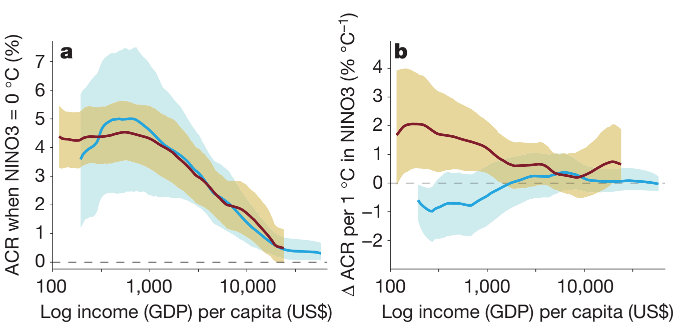


**Figure 3 | ENSO, ACR and income.** For each country $i$, we estimate $ACR_i(t) = \alpha_i + \beta_i NINO3(t)$. **a**, Baseline ACR ($\alpha_i$) against log income per capita in 2007 (moving average, 90% confidence intervals shaded). Teleconnected (weakly affected) group in red (blue), $n = 85$ ($n = 75$). **b**, Same, but for the sensitivity of ACR to ENSO ($\beta_i$).

Our results do not provide an estimate for the full value of a global climate state, but we can compare the global climate to income in terms of their individual associations with ACR. In a teleconnected country where average income per capita is US$1,000 ($\alpha_i = 4\%$, $\beta_i = 1\%$ °C$^{-1}$), the 3 °C shift associated with a change from La Niña to El Niño increases ACR by 3% (Fig. 3b). This change has the same magnitude as the 3% drop in baseline ACR that is associated with increasing average income tenfold (Fig. 3a).

Because the strong ENSO events that have the greatest influence on ACR may be predictable up to 2 years in advance[23], use of our findings may improve global preparedness for some conflicts and their associated humanitarian crises.

We find that the changes in the global climate driven by ENSO are associated with global patterns of conflict, but our results might not generalize to gradual trends in average temperature or particular characteristics of anthropogenic climate change. Generalizing our results to global climate changes other than ENSO will require an understanding of the mechanisms that link conflict to climate. ENSO has a proximate influence on a variety of climatological variables, each of which may plausibly influence how conflict-prone a society is. Precipitation, temperature, sunlight, humidity and ecological extremes can adversely influence both agrarian[20,24] and non-agrarian economies[21,22]. In addition, ENSO variations affect natural disasters, such as tropical cyclones[25], and trigger disease outbreaks[26]. All of these have adverse economic effects, such as loss of income or increasing food prices, and it is thought that economic shocks can generate civil conflict through a variety of pathways[1,3,18]. Furthermore, altered environmental conditions stress the human psyche, sometimes leading to aggressive behaviour[27]. We hypothesize that El Niño can simultaneously lead to any of these adverse economic and psychological effects, increasing the likelihood of conflict. Furthermore, the influence of ENSO may exceed the sum influence of these individual pathways because it is a global-scale process that generates simultaneous and correlated conditions around the world. This is possible if non-local processes, such as increasing global commodity prices[28] or conflict contagion[6,18], strongly influence local conflict risk. Future work will examine the relative importance of these various mechanisms.

## METHODS SUMMARY

Pixels with surface temperatures significantly and positively correlated with NINO3 for at least 3 months out of the year are coded 'teleconnected'; remaining pixels are coded 'weakly affected'. Countries are coded teleconnected (weakly affected) if more than 50% of the population in 2000 inhabited teleconnected (weakly affected) pixels. Group-level time-series regressions (Table 1, models 1–4) use a continuous variable for ACR; we drop 1989 because it is a 3$\sigma$ outlier, presumably because of the end of the Cold War. Group-level standard errors are robust to unknown forms of heteroscedasticity. Country-level longitudinal regressions (models 5 and 6) are linear probability models for conflict onset with standard errors that are robust to unknown forms of spatial correlation over distances no more than 5000 km, serial correlation over periods no more than 5 years and heteroscedasticity[21]. We estimate the number of conflicts associated with ENSO by assuming all conflicts in the weakly affected group were unaffected and a baseline ACR of 3% for the teleconnected group would have remained unchanged in the absence of ENSO variations. We then project the observed sequence of NINO3 realizations onto our linear conflict model ($dACR/dNINO3 = 0.0081$) and find 48.2 conflicts (21%) were associated with ENSO. For additional details on methods, see Supplementary Methods and replication files in Supplementary Data.

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**Supplementary Information** is linked to the online version of the paper at www.nature.com/nature.

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**Author Contributions** S.M.H. conceived and designed the study. S.M.H. and K.C.M. conducted the analysis. S.M.H., K.C.M. and M.A.C. wrote the paper.

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