Mountainous Terrain and Civil Wars: Geospatial Analysis of Conflict Dynamics in the Post-Soviet Caucasus

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Existing research on the relationship between mountainous terrain and conflict has generally been implemented using crude metrics capturing the actions and motivations of armed groups, both insurgent and government. We provide a more geographically nuanced investigation of two specific propositions relating mountainous terrain to violent conflict activity. Our study covers five wars in the Caucasus region: the second North Caucasus war in Chechnya and neighboring republics (1999–2012); Islamist and Russian government conflict in the same area (2002–2012); fighting between Armenians and Azerbaijanis in Nagorno-Karabakh (1990–2012); and battles between Georgia and separatists in South Ossetia (1991–2012) and Abkhazia (1992–2012). Our analysis of insurgent and government violence reciprocity illustrates some expected patterns of what we call the operational costs of context. By varying the dimensions for our units of analysis—the context within which violent interactions take place—however, we arrive at differing conclusions. Our research represents a meaningful and transparent engagement with the influences of the well-known and understudied modifiable areal unit problem (MAUP) in geographically sensitive analysis. *Key Words: Caucasus, conflict, modifiable areal unit problem, political geography, spatial analysis.*

山区和冲突间的关係之研究, 一般透过运用粗糙的指标, 同时捕捉作为反抗和政府组织的武装团体的行动及意图。我们为连结山地与暴力冲突活动的两个主张, 提供地理上更为细緻的探讨。我们的研究涵盖高加索地区的五场战役: 在车臣及周围的共和国发生的第二次北高加索战役 (1999 年至 2012 年); 在同一地区中的伊斯兰与俄罗斯政府间的冲突 (2002 年至 2012 年), 亚美尼亚人与阿塞拜疆人在纳戈尔诺-卡拉巴赫发生的战争 (1991 年至 2012 年), 以及格鲁吉亚和分离主义者在南奥赛梯的战役 (1992 年至 2012 年) 。我们对于反抗和政府暴力互动的分析, 描绘出我们称之为脉络操作成本的若干预期模式。但透过多样化分析单元的各个面向——暴力互动所发生的脉络——我们却得到了不同的结论。我们的研究, 呈现对具有地理敏感度的分析中为人所熟知且未被充分研究的可调整地区单元问题 (MAUP) 进行有意义且透明的涉入。 *关键词: 高加索, 冲突, 可调整地区单元问题, 政治地理学, 空间分析。*

La investigación existente sobre las relaciones entre terreno montañoso y conflicto ha sido implementada, en general, con el uso de métricas crudas para captar las acciones y motivaciones de los grupos armados, tanto de insurgentes como de los gobiernos. Lo que nosotros entregamos es una investigación de matices más geográficos sobre dos proposiciones específicas que relacionan el terreno montañoso con las actividades del conflicto violento. Nuestro estudio cubre cinco guerras en la región del Cáucaso: la segunda guerra del Norte del Cáucaso en Chechenia y las repúblicas vecinas (1999–2012); el conflicto islamista con el gobierno ruso en la misma área (2002–2012); la lucha entre armenios y azerbaiyanos en Nagorno-Karabakh (1990–2012); y las batallas entre Georgia y los separatistas en Osetia del Sur (1991–2012) y Abkhazia (1992–2012). Nuestro análisis de la reciprocidad en violencia de insurgencia y gobierno ilustra algunos de los patrones esperados de lo que nosotros denominamos costos operacionales del contexto. Sin embargo, variando las dimensiones de nuestras unidades de análisis—-el contexto dentro del cual tienen lugar las interacciones violentas—-llegamos a diferentes conclusiones. Nuestra investigación representa un compromiso significativo y transparente con las influencias del bien conocido como poco estudiado problema de la unidad areal modificable (MAUP, acrónimo en inglés) en análisis geográficamente sensible. *Palabras clave: Cáucaso, conflicto, problema de la unidad areal modificable, geografía política, análisis espacial.*

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Scholars in the field of conflict studies have increasingly adopted geographical statistical analyses for their research. Unfortunately, many still engage with geography superficially. We believe that the study of mountainous terrain and civil war violence especially suffers from conceptual–empirical incompatibility. We highlight the important difference between studying civil war in the aggregate and analyzing violence dynamics that take place within civil wars. Our study improves on existing research in the literature with better data and statistical methodologies designed to capture the geographical contexts within which violence emerges and develops over time. Our analysis of violence in the North and South Caucasus calls into question any simplistic narrative about how rugged terrain relates to conflict dynamics.

Conflict analysts incorporate geography into their research in several ways. The first is through a concern for spatial and temporal disaggregation of research questions and statistical methods. Investigations of riots in London (Baudains, Johnson, and Braithwaite 2013), government-opposition attacks in Iraq (Linke, Witmer, and O'Loughlin 2012), Bosnian civil war events (Weidmann and Ward 2010), or Islamist insurgent activity in the North Caucasus (Zhukov 2012) all demonstrate the merits and utility of localizing violence research.

A second area of attention for geographical conflict research centers on diffusion or contagion effects. Studies in this vein adopt epidemiological language describing conflict as a force spreading across regions according to underlying political or economic processes (Houweling and Siccama 1985; Buhaug and Gleditsch 2008; Schutte and Weidmann 2011; Linke, Schutte, and Buhaug 2015). Geographers emphasize that diffusion also takes place within and across social network structures in addition to territorial connections (Medina and Hepner 2011; Radil, Flint, and Chi 2013).

Third, the compositional quality of a location (whether a town or region) might influence conflict patterns, and these characteristics can be inherently geographical. The geographic distribution of ethnic communities (Toft 2003; Weidmann and Saleyhan 2012), for example, has important implications for representation in a country's political institutions and can therefore translate into intergroup disputes. Contentious politics might or might not become violent depending on the distribution of territorial homelands, political accommodations, or as a function of social interactions that take place within demographically diverse versus homogenous areas.

A survey of the violent conflict literature reveals a prevailing reliance on this third understanding of geography. Some exceptions to the simplified idealization of geography exist, including Daly (2012), who, in her study of Colombia's civil conflict, embraced "a reorientation away from physical geography and back to the human and social geography that determines if rebellion is organizationally feasible" (473; see also Buhaug and Gates 2002). More specifically, conflict researchers often confine geography to physical geographic considerations instead of also including human geography. In particular, mountainous terrain and forest cover are commonly identified as correlates of violence in the classical civil war literature (Guevara 1961; McColl 1969; Grundy 1971; Fearon and Laitin 2003; Do and Iyer 2010; Nemeth, Mauslein, and Stapley 2014). The difference between social and physical understandings of geography across disciplines is linked with an understanding that "place" (the human geography emphasis) is more than only "space" (which tends to dominate in political science; O'Loughlin 2000). Our current goal is to advance the study of mountainous terrain influences on violence between government and nonstate actors. In doing so, we study group interaction dynamics of conflicts (the endogenous elements) against the background of particular elevation profile contexts (the exogenous elements).

In their study of civil war violence in sub-Saharan Africa, Tollefsen and Buhaug (2015) tested the effects of opposing actors' accessibility for intrastate armed conflict. They included structural variables like road networks, distances to capital cities, and mountainous terrain in addition to "sociocultural inaccessibility," which is related to demography and institutional exclusion of ethnic communities. The expected relationship to mountainous terrain is that armed opposition to the state thrives where there is sanctuary for organizational activities of insurgents. Sanctuary can, of course, be political if it is related to international borders (Saleyhan 2009), but it can also be social if it is related to identity politics and information sharing (e.g., denouncing militant activities to a counterinsurgent campaign, as in Lyall 2010).

Terrain and conflict research can be improved by focusing on scales of analysis and geographical context. There is currently limited evidence of a correlation between mountains and conflict (Buhaug and Rød 2006; Hegre and Sambanis 2006; Rustad et al. 2008) despite anecdotal accounts and selective narratives of such a link. The majority of research, however, is carried out with crude measurements and with a single unit of analysis (whether subnational or at a country level). Exceptions include O'Loughlin, Witmer, and Linke (2010), who aggregated insurgent and government force violent events in Afghanistan and compared trends along flat and hilly terrain profiles. Also using subnational analysis, Tollefsen and Buhaug (2015) found positive statistical associations between inaccessibility due to poor transport and the risk of violent intrastate conflict. We follow these two approaches and make several improvements by: (1) focusing more closely on reciprocal engagements between government and insurgent forces; (2) investigating a comparatively limited range of cases, which reduces the potential for unobserved influences; and (3) using a more geographically precise event data analysis.

The five North and South Caucasus wars that we study have their origins in the shared legacy of the Soviet state and its federal system. For each, the rubric of third-tier polities in the Soviet federal hierarchy (autonomous Soviet socialist republics (SSRs) and autonomous oblasts) opposing second-tier units (then union republics, which are now independent states) explains the origins of political tension. These conflicts "came from the peculiar existence of nations within nations, a phenomenon which may be referred to as '*matrioshka nationalism*'" (Bremmer 1997, 11–12). The Soviet national-territorial arrangement promoted regional autonomy movements, which at the end of the USSR turned to conflict as a mechanism to achieve their political aims (Cornell 2002).

In Nagorno-Karabakh (see Figure 1), a majority Armenian region that was part of the Azerbaijani SSR, local parliamentarians issued a resolution on the transfer of the region to the Armenian republic in February 1988. Moscow's reaction was tentative and local interests responded decisively. According to de Waal (2003, 15), "The slow descent into armed conflict began" the day the resolution passed; the war in Nagorno-Karabakh continued with periods of intense fighting until 1994 and left approximately 25,000 dead. All Azerbaijanis were displaced from the region. Border skirmishes between the two sides continue to this day. A similar politics of territorial designation emerged in South Ossetia and Abkhazia (Georgia), and Chechnya (Russia). In each case, local nationalist leaders put forward a movement toward independence from the Soviet republics. In South Ossetia, fighting between paramilitaries ran from January 1991 through June 1992 and claimed roughly 1,000 lives. The war in Abkhazia, during 1992 and 1993, "was a failed attempt to subordinate and incorporate this previously autonomous region into a newly unified and centralized Georgian state" (O'Loughlin, Kolossov, and Toal 2011, 4). The outcomes of these wars in terms of fixed delimited borders and extensive displacement of ethnic Georgians were formalized following the August 2008 conflict between Georgia and the two de facto states, aided by their Russian patron. The first war in Chechnya began in December 1994 and ended in a tentative peace agreement in August 1996. When Chechen militants—most notably Shamil Basayev—sought a more decisive resolution to the first war by territorial expansion and invaded neighboring Dagestan, the Russian government responded with substantial force. The conflict later developed into a regional-scale insurgency that adopted Islam as its motivating ideology. In the early years of the second Chechen war, fighting was particularly intense in and near the republic's capital of Grozny; the insurgency subsequently diffused to the neighboring republics of Ingushetia and Dagestan (O'Loughlin, Holland, and Witmer 2011).

Identifying Conflict Processes

The central theme in terrain-related conflict research is that mountainous regions favor insurgency as an organizational mode of conflict (Fearon and Laitin 2003). *Insurgencies* are defined as "a technology of military conflict characterized by small, lightly armed bands practicing guerilla warfare from rural base areas" (Fearon and Laitin 2003, 75). Because these groups are small and lightly armed, they move easily to camps and exploit clandestine networks to hide while conducting operations. Heavily armed, slow-moving governmental forces, in contrast, typically experience difficulty in their efforts to project power into isolated regions; government forces are paradoxically burdened by equipment that should ensure their military dominance.

Boulding's (1962) loss-of-strength gradient is the key conceptual link between social and physical geography in this line of research. Distance from population centers and peripheral locations for rebel activities play an important role in determining the potential for rebel organization, recruitment, and training (Buhaug and Gates 2002; Cunningham, Gleditsch, and Saleyhan 2009). State militaries, police, and other forces are more likely to be weak in rural and geographically marginalized areas of a country (Grundy 1971; Hegre 2008; Pickering 2012). Our cases exemplify these political circumstances (e.g.,

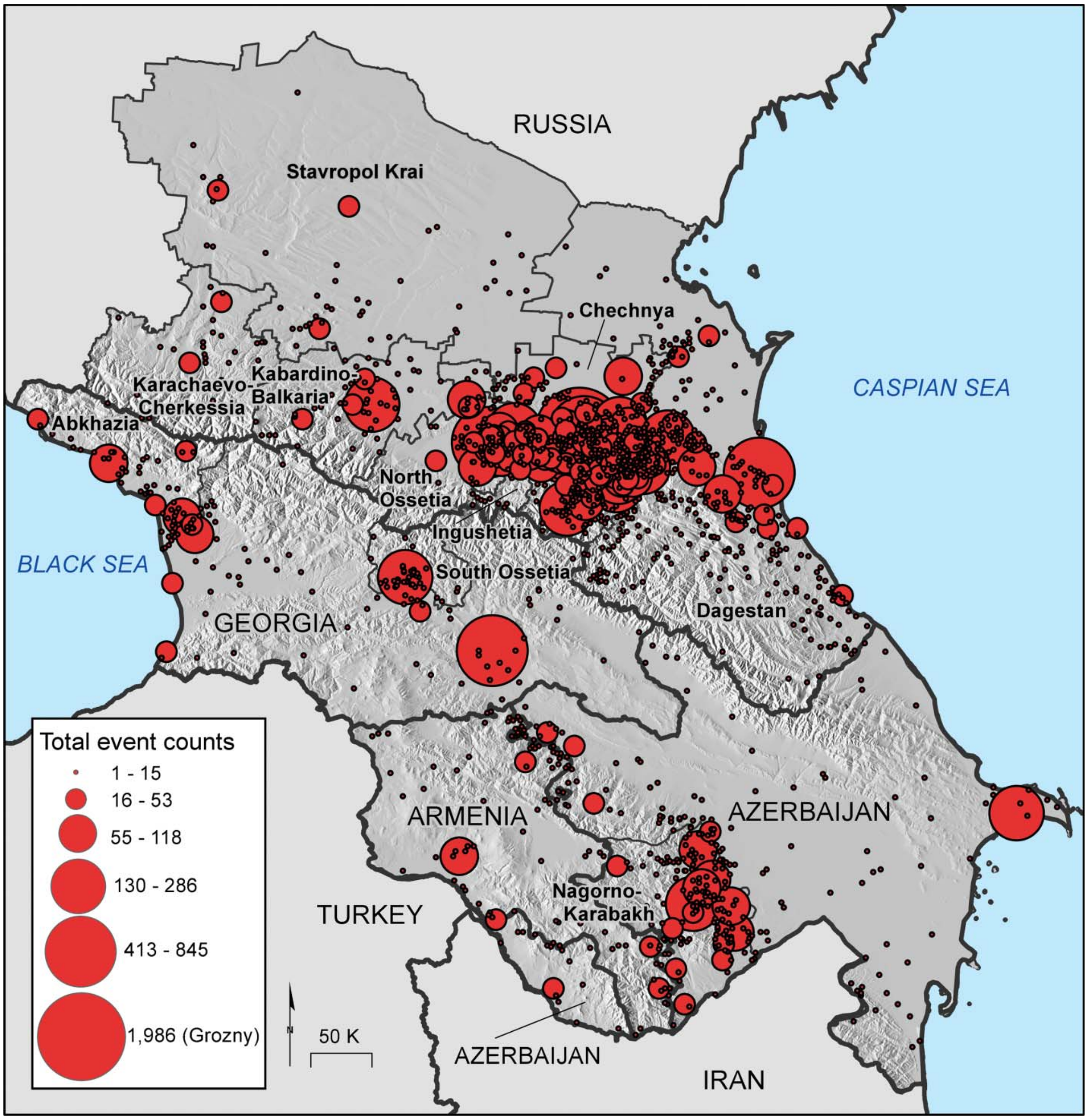

Figure 1. Graduated circles represent the number of violent events aggregated to the nearest kilometer (Universal Transverse Mercator Zone 38N), which avoids excessive overlap in the graphic. The terrain hillshade is generated from Shuttle Radar Topography Mission elevation data. (Color figure available online.)

Georgia's wars in both South Ossetia and Abkhazia), where contested sovereignty arises (Kolstø 2006).

Grundy (1971) argued that in the context of guerilla war, "a few square miles of mountainous jungle may be as strategically invulnerable as, let us say, a hundred square miles of prairie or, perhaps, a thousand square miles of flat plain crisscrossed by roads and telephone wires and dotted with airstrips and radio transmitters" (45). Fearon and Laitin (2003, 85) found that, controlling for political and economic factors, a country that is "half mountainous" (90th percentile of their sample) has a 13.2 percent risk of experiencing civil war; they found that a similar country that is not mountainous should expect a 6.5 percent risk of major armed conflict. Similar recent research finds that mountainous terrain is associated with proportionally more terrorist attacks (Nemeth, Mauslein, and Stapley 2014). Activity by the government side, however, is completely absent from this analysis, which is a serious limitation of the study. It is not clear from the current literature how exactly collective violence on the ground relates to terrain.

Our specific propositions are based on an understanding of constraints that shape both government and non-state actor capabilities. As the stated goal of each is to confront the other, our interest is in clarifying the structural conditions that either party uses to its advantage.

We rely on the notion of reciprocity; a plausible scenario is that where one actor conducts a strike against an opponent, the other party reacts by conducting operations nearby in location and time (see Linke, Witmer, and O'Loughlin [2012] for a more comprehensive exposition of reciprocity dynamics). We do not rely on a strict definition for the location of possible reactions and instead examine the effects across dozens of models using variable definitions of the range of response from 10 to 50 km^2 and including *rayon* (county) administrative units.[1] Our objective is not explaining the onset of the Caucasus wars at the most general level but focusing on their dynamics across terrains and sociodemographic contexts.

We anticipate that each conflict actor will experience operational costs in particular contexts or settings. Such costs for insurgents might include ease of accessing military equipment. Governments, in turn, suffer the burden of operational costs where terrain is impassible and guerilla fighters can hide, equip, and muster support for their cause undeterred. These conditions represent what we call the "operational costs of context," which vary substantially by mountainous terrain profiles. Observable implications of the theory can be tested in two specific propositions:

1. In high neighboring terrain regions, insurgent reciprocity (violent action) for a government-initiated event will be stronger than government reciprocity. Insurgents have a "sanctuary" advantage in such areas.
2. In low neighboring terrain regions, government reciprocity (violent action) for an insurgent-initiated event will be stronger than insurgent reciprocity. Government forces have an occupier control advantage in such areas.

Our expectations are illustrated graphically in Figure 2 in a straightforward schematic. For each type of region (I for higher neighboring terrain and II for lower), we test how well insurgent violence predicts government violence (result a) and vice versa (result b). The sign of the expected relationship is shown in parentheses.

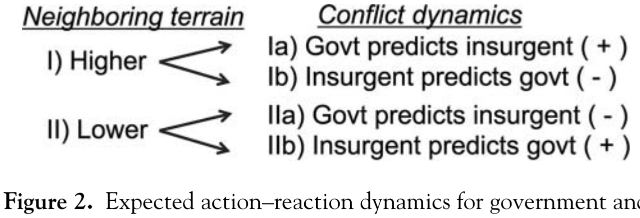

Figure 2. Expected action–reaction dynamics for government and insurgent violence in low and high neighboring terrain contexts.

To take into account modifiable areal unit problem (MAUP) concerns (Openshaw 1983), we use four spatial units of analysis. Figure 3 shows the definition of each areal unit across our study region. MAUP issues are not only a technical dilemma but also represent theoretical questions about the dimensions of geographical context and the ranges of social interaction (for a demonstration of MAUP's importance in conflict analysis, see Linke and O'Loughlin 2015).

Conflict Events, Elevation, and Social Control Variable Data

Descriptive statistics for all of our data at 25 km^2 are presented in Table 1 (see our Supplemental Material for the statistics at other spatial resolutions). Original conflict events data for our research were gathered from media sources and coded following the format of the Armed Conflict and Location Event Data project (Raleigh et al. 2010). Research assistants searched Lexis-Nexis archives for reporting of events that involved violence (including terms such as *attack*, *strike*, and *bomb*, among many others). All reports are stored and checked against duplicate stories to verify the information's accuracy. Each conflict incident is then entered in a data set with the date, perpetrating actor, location, type of event (e.g., suicide bombing), and notes providing any additional information. Unknown actors are included in our data if the violent incident was reported with location, time, and event type explained in detail. The North Caucasus data have been used in other related studies (e.g., O'Loughlin, Holland, and Witmer 2011; O'Loughlin and Witmer 2011); South Caucasus data were coded for this extended analysis. Figures 4 and 5 show the distribution of violent events over time.

Because we focus on interactive dynamics of insurgent and government forces, we aggregate actors into broader classifications. Police, secret police, border patrols, and military forces of any internationally recognized state are classified as government actors. We allow for this broad definition of government actors because the police and border guards often perpetrate violent seizures, and patrol activities can also lead directly to confrontations. Our designation for insurgent actors includes all known Islamist groups, ethnonationalist political parties and movements, and unknown but nonstate perpetrators of violence.

We do not require that insurgent and government forces interact directly in a single incident. In other words, a militant might detonate a suicide bomb that

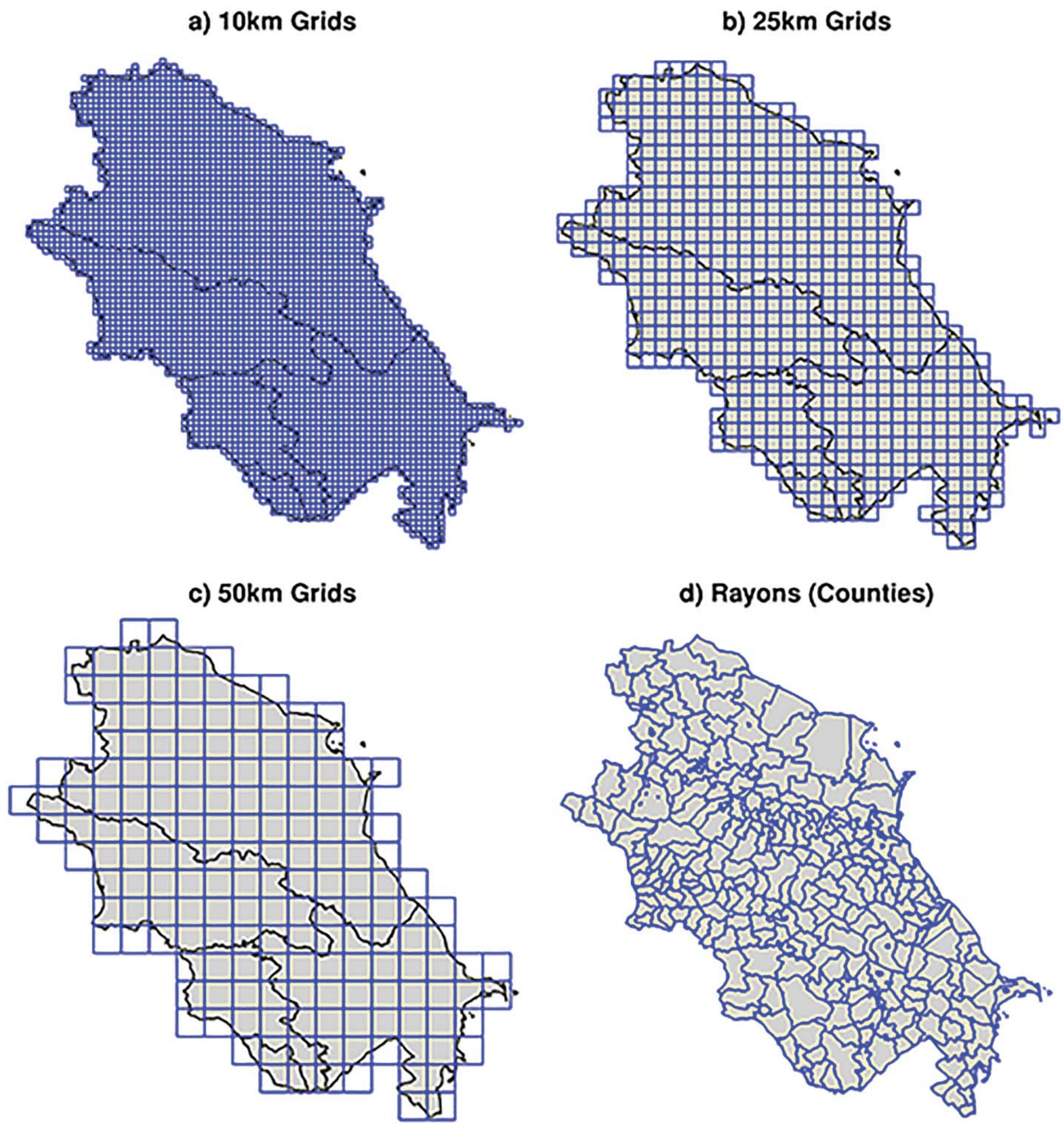

Figure 3. Multiple grid cell dimensions of (A–C) 10 to 50 km^2 and (D) *rayon* administrative units mapped over the study area. (Color figure available online.)

kills civilians in a marketplace in Vladikavkaz, North Ossetia (as occurred in September 2010). Alternatively, a police sweep through an area that results in unarmed civilians being killed will appear in our data even if the police sweep never encountered members of an Islamist *jamaat* (group or congregation). The political violence literature explains that in cases of contested territorial control, violence is often used against civilians with strategic purpose (Kalyvas 2006). A terrorist attack that does not directly target the president could still clearly undermine the legitimacy of a regime or sway the opinion of residents to encourage defection and denunciation.

We apply a geographic projection of the conflict event locations to Universal Transverse Mercator (UTM) Zone 38N and merge all outcome, predictor, and control variable data in grid cells and rayons that are defined by a monthly temporal resolution. Mean elevation is calculated from the 30 m Shuttle Radar Topography Mission (SRTM) data for each unit of analysis (Farr et al. 2007). We use first-order neighbor contiguity to measure variables for neighboring units of analysis. We are particularly interested in the conflict dynamics that operate within terrain zones and not only in "controlling away" the effects of elevation or estimating the direct influence of elevation on

Table 1. Summary statistics for all variables used in our models at the 25 km^2 resolution

Variables	Min	Median	M	Maximum	SD
All events	0.000	0.000	0.123	101.000	1.324
Government events	0.000	0.000	0.072	72.000	0.890
Government events spatial lag	0.000	0.000	0.073	17.375	0.470
Rebel events	0.000	0.000	0.047	36.000	0.529
Rebel events spatial lag	0.000	0.000	0.047	7.500	0.266
Titular percent	0.000	84.296	65.244	100.000	37.800
Employed percent	2.589	14.587	14.941	38.447	5.116
Urban percent	0.000	25.159	27.047	100.000	20.773
Population size (1,000s)	2.424	6.552	6.493	10.078	1.049
Forest cover (percent)	0.000	5.572	16.093	84.556	20.267
Border distance (km)	1.058	3.812	3.669	5.802	1.217
Distance to road (km)	0.263	3.004	3.274	14.621	1.454

conflict absent any conditional effects. Therefore, we create two subsets of the data set based on the difference between the elevation of a given unit and the average of the neighboring units (a threshold of 50 m or greater was used because most locations in the study area are surrounded by higher terrain). We refer to these as higher neighboring elevation and lower neighboring elevation. A map of the designation for 25 km^2 grid cells is shown in Figure 6.

We strive to control for possible alternative explanations of conflict, including poverty (Buhaug et al. 2011), excluded ethnicity status (Wimmer 2002), population size (Raleigh and Hegre 2009), and infrastructure such as roads (Zhukov 2012). Percentage titular measures the proportion of the nominal ethnic group (e.g., Georgians) in each of the four countries and their de facto territories. We include this variable because we expect areas with low levels of titular nationals to be more likely to engage in violent struggles for autonomy. We collect these data from the most recent publicly available census information. South Ossetia was a notable exception; percentage titular is 20 percent based on estimates made by the International Crisis Group (2010) after the August 2008 war there. In each of the three de facto states, the titular nationality of the parent states—Georgian for Abkhazia and South Ossetia and Azerbaijani for Nagorno-Karabakh—is used for consistency across cases and in partial acknowledgment of the undetermined status of these polities.

Where possible, census data are also used to calculate percentage urban population within subnational units to control for the relationship between city location and observed violence. In Georgia, Azerbaijan, and Armenia, percentage urban is reported in the most recent censuses. The Russian state statistical agency, Goskomstat, maintains a database of economic indicators for municipalities. In the de facto states, measures of percentage urban are reported inconsistently across data sources. Nagorno-Karabakh Republic includes this information in the regional-level results of the 2005 census. For Abkhazia and

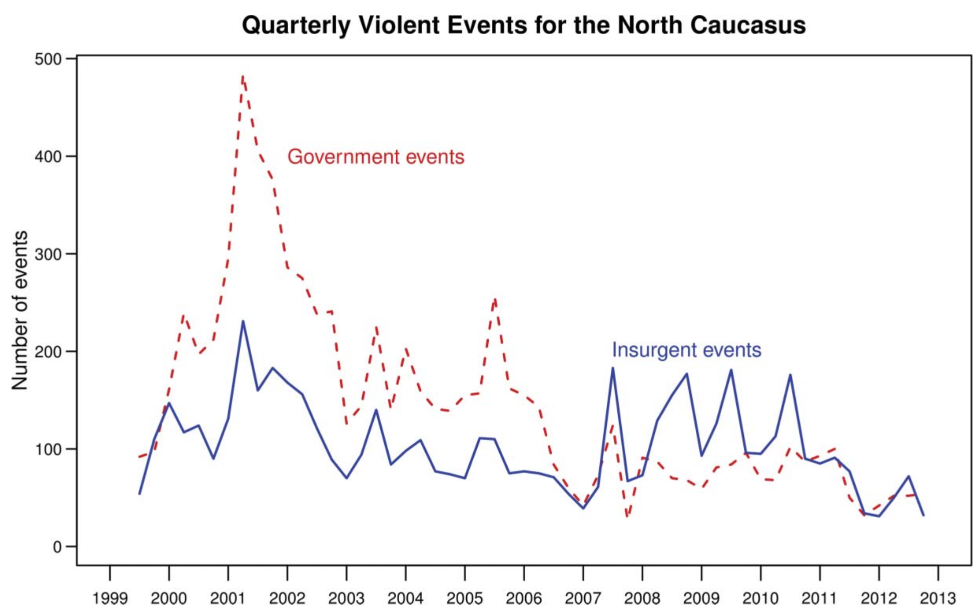

Figure 4. North Caucasus insurgent (solid) and, separately, government (dashed) violence by three-month periods between 1999 and 2012. (Color figure available online.)

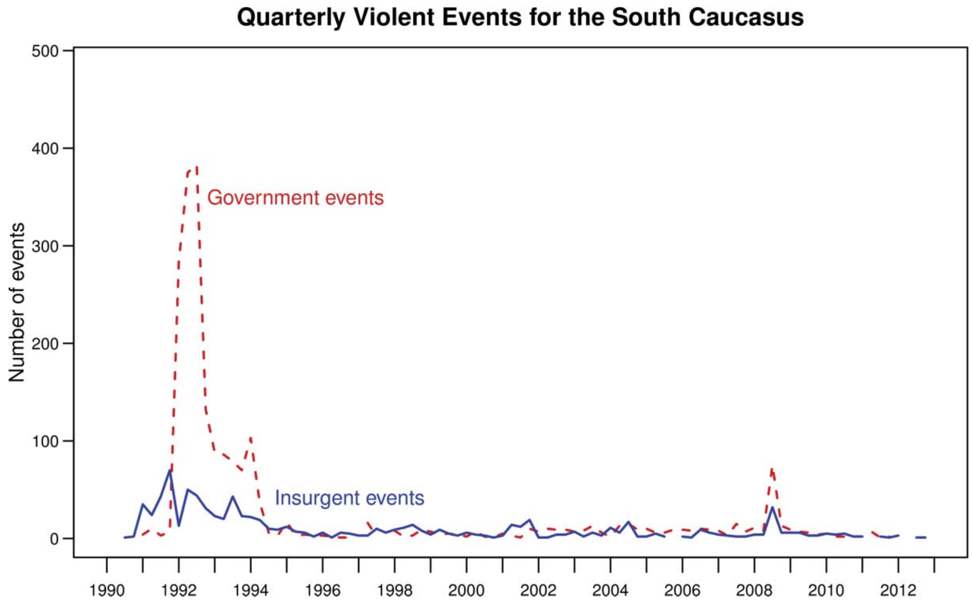

Figure 5. South Caucasus insurgent (solid) and, separately, government (dashed) violence by three-month periods between 1990 and 2013. (Color figure available online.)

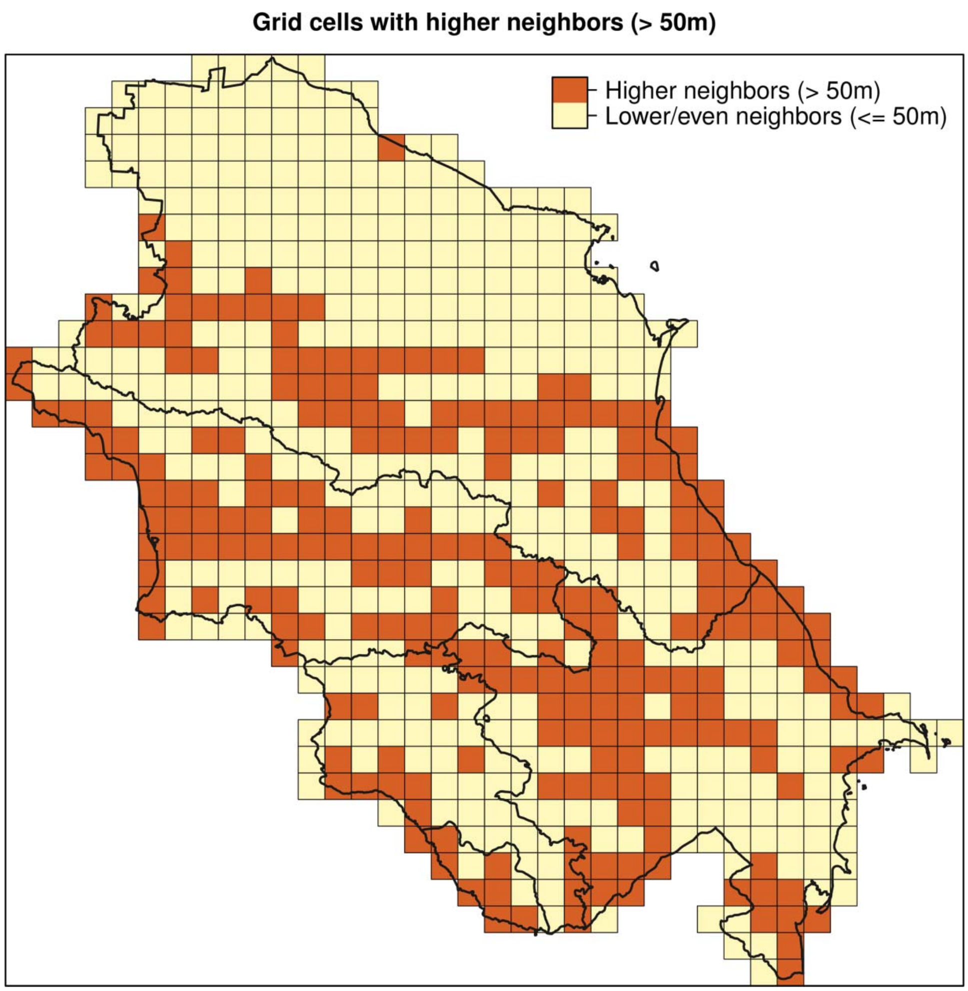

Figure 6. By 25 km^2 grid cell units of observation, the designation of higher (dark cells) and lower (light cells) neighboring terrain variables across the study area. Of 641 grid cells, 242 are designated as higher neighboring terrain and 399 as lower. (Color figure available online.)

South Ossetia, we generate estimates on the percentage urban from the results of two separate surveys conducted in the regions in March and November 2010, respectively (O'Loughlin, Kolossov, and Toal 2011; Toal and O'Loughlin 2013).

Percentage employed is intended as a proxy for the level of economic development or wealth in the subnational units as well as a measure of state capacity. To more fully evaluate the latter condition, we collect data on the percentage of people employed in either government or private business. Constructing the variable in this fashion leaves out respondents who indicate that they are self-employed. Where these data were not available in the most recent census, we use the most current available data from other governmental sources. For the de facto states of Abkhazia and South Ossetia, this metric is based on the results of our two 2010 surveys.

Our population data are from the Center for International Earth Science Information Network (CIESIN 2004) for the year 2000 and are static throughout the time series. We aggregate the population raster image within our grid cells using an area-weighted zonal statistic. We log transform these data for our analysis because they are highly skewed.

We have three structural and physical geographical controls. Percentage forest cover is calculated as the mean tree cover in each unit of analysis for the year 2000. This metric is derived from Landsat imagery with each unit assigned the percentage of closed vegetation canopy taller than 5 m in height (Hansen et al. 2013). Distance to an international border is calculated by creating a 2 km^2 raster layer where each pixel represents the distance to the nearest international border. From this raster image, the mean distance to a border is measured for each unit. This variable is log-transformed in our analysis. Distance to a road is similarly calculated using a finer resolution raster layer and taking the mean value within every unit. The road data are from version one of the Global Roads Open Access Data Set (gROADS; CIESIN 2013).

Methods

Our estimation captures the effect of violence perpetrated by either the government or insurgents at time $t-1$ (an action) on the opposing party's behavior during time t (the reaction). Each proposition for the corresponding terrain type calls for a comparison of coefficients from two regression models:

$$Y_{Git} = \beta_0 + \beta_1 Z_{Git-1} + \beta_2 Z_{Iit-1} + \beta_3 X_{it} + f_1(UTM\_E,\ UTM\_N) + f_2(M) + R_{it} + e_{it} \quad (1)$$

and

$$Y_{Iit} = \beta_0 + \beta_1 Z_{Git-1} + \beta_2 Z_{Iit-1} + \beta_3 X_{it} + f_1(UTM\_E,\ UTM\_N) + f_2(M) + R_{it} + e_{it}, \quad (2)$$

where Y_{Git} is the outcome measurement of violent events by government (G) forces in spatial unit i for month t. In Equation 1, coefficient β_1 captures the influence of the control variable for prior government events, Z_G, in the neighboring area at $t-1$. β_2 is the quantity of interest, measuring how strongly previous insurgent violence (Z_{Iit-1}) predicts government violent events. Vector β_3 captures the influence of the matrix of controls X. β_0 is the model intercept and e_{it} measures unexplained error. A thin plate spline smoothing function, f_1, is applied to the easting and northing UTM location coordinates and f_2 is a similar spline for the month identifier, M. Each model estimate includes fixed effects (R) for the republic (e.g., Dagestan) or country (e.g., Georgia). Equation 2 differs from Equation 1 in two ways. First, the outcome Y_{Iit} is the count of insurgent events (I) per unit month (it) instead of government incidents. Second, the quantity of interest is β_1, measuring the influence of prior nearby government events (in Equation 1 this was a control variable for prior activity).

Most observational data are characterized by spatial dependencies (Anselin 1988) and we address this in our estimation. First, each model includes a space–time-lagged measurement of the actor-specific conflict event outcome. Second, we use a generalized additive model (GAM) with a spatial smoothing term for the location coordinates of each unit of observation (see Wood [2004, 2006], and an application to conflict analysis in Zhukov [2012]). Similar to the implementation in Wood (2004), our GAM method controls for the effect of location on the outcome of interest.

Our overdispersed event counts outcome variable calls for a negative binomial functional form; this distribution requires a theta (θ) dispersion parameter that we estimate from an identically specified generalized linear model (these initial GLM model results are not reported). We cluster standard errors at the unit of

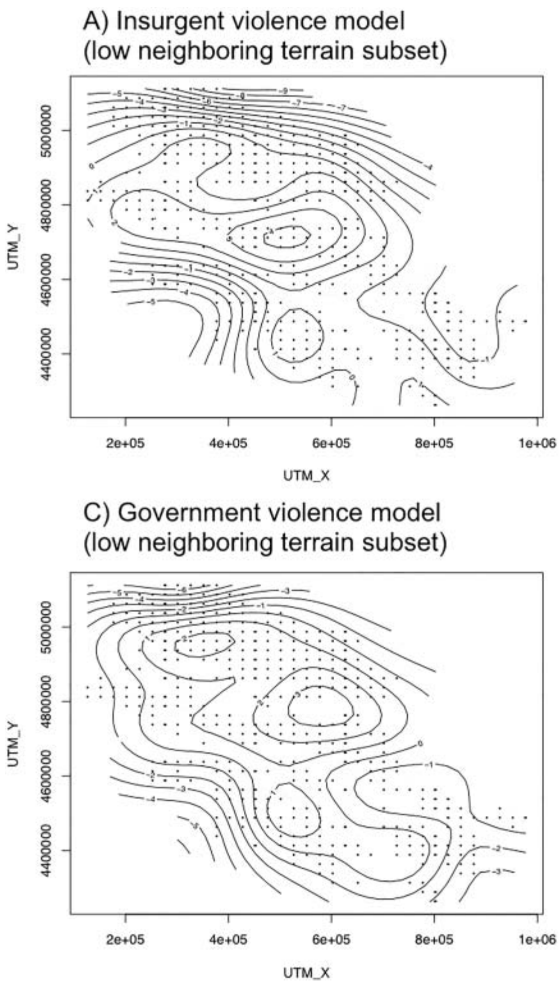

Figure 7. Spatial smoothing terms (or "splines") of our 25 km^2 generalized additive models mapped across the study area. Black dots represent the centroid of each grid cell. The models presented in A through D correspond to our main propositions.

analysis. In Figure 7 we map the coefficients of the spatial smoothing term for the 25 km^2 grid cell resolution as an example of the methodology. The influences of locational context are clearly visible across models (Figures 7A–7D). See the Supplemental Material for the temporal smoothing term.

Results

Our spatial analysis results are presented in Table 2. The main estimate to interpret for each actor is the term measuring the spatial lag of the opposing side's activity at time $t - 1$ (shown in bold). Results from logistic and Poisson regression analyses are presented in our Supplemental Material as robustness tests.

To evaluate the propositions, we compare model results across terrain subsets. Model numbers in Table 2 correspond directly to Figure 2. The estimate for government reactions to insurgent events in the higher neighboring terrain subset (Model Ib) is compared with the insurgent reactions to government events also in the higher neighboring terrain subset (Model Ia). Using a 25 km^2 resolution we find that every government-initiated conflict event is associated with 9.5 percent more insurgent violence in the following time period (0.091 increase in log event count). In contrast, government reactions to insurgent events in this context are not statistically significant, lending support to our first proposition. Our analysis thus suggests that nonstate armed actors enjoy a strategic advantage in areas with higher nearby terrain.

The related second proposition, which posits that governments would enjoy advantages that result in stronger reciprocity in lower neighboring terrain regions, has no support. The estimates of both insurgent reactions (Model IIa) and government reactions (Model IIb) in areas with lower neighboring elevation

Table 2. Spatial generalized additive model results including all indicators of interest, control variables, and model diagnostics for each spatial resolution

	Higher neighboring terrain (I)						Lower neighboring terrain (II)					
	Insurgent event predictors (Model Ia)			Government event predictors (Model Ib)			Insurgent event predictors (Model IIa)			Government event predictors (Model IIb)		
	Est.	SE	*p*	Est.	SE	*p*	Est.	SE	*p*	Est.	SE	*p*
25 km² spatial resolution												
(Intercept)	−12.923	2.015	0.000	−12.332	1.891	0.000	−15.096	2.454	0.000	−10.390	2.137	0.000
Spatial lag insurgent events	0.403	0.058	0.000	***0.012***	***0.059***	***0.834***	0.572	0.104	0.000	***−0.089***	***0.136***	***0.512***
Spatial lag government events	***0.091***	***0.033***	***0.006***	0.304	0.031	0.000	***−0.048***	***0.068***	***0.481***	0.372	0.077	0.000
Titular percentage	−0.002	0.007	0.823	0.007	0.006	0.243	−0.036	0.011	0.001	−0.017	0.008	0.048
Employed percentage	0.099	0.047	0.036	0.087	0.034	0.011	−0.049	0.059	0.409	−0.042	0.042	0.315
Urban percentage	0.012	0.010	0.202	0.006	0.008	0.454	0.021	0.013	0.108	0.015	0.010	0.124
Population (ln)	0.797	0.152	0.000	0.784	0.161	0.000	1.063	0.178	0.000	0.879	0.162	0.000
Forest cover (ln)	−0.005	0.006	0.404	−0.011	0.006	0.074	0.003	0.013	0.815	0.011	0.011	0.333
Border distance (ln)	−0.601	0.197	0.002	−0.548	0.197	0.005	0.697	0.514	0.175	−0.106	0.272	0.695
Road distance (ln)	−0.210	0.153	0.169	−0.228	0.153	0.136	−0.067	0.140	0.634	−0.097	0.135	0.473
θ	0.574			0.262			0.125			0.091		
AIC	14884.4			18648.7			7728.1			10345.9		
AUC	0.945			0.942			0.938			0.928		
N	55,598			55,598			81,550			81,550		
DV events	4,953			7,812			1,466			2,059		
10 km² spatial resolution												
(Intercept)	−12.523	1.582	0.000	−11.338	1.608	0.000	−13.474	1.810	0.000	−12.866	1.842	0.000
Spatial lag insurgent events	0.969	0.307	0.002	***0.363***	***0.265***	***0.171***	0.895	0.177	0.000	***0.276***	***0.201***	***0.170***
Spatial lag government events	***0.240***	***0.132***	***0.069***	0.970	0.107	0.000	***0.003***	***0.085***	***0.970***	0.409	0.097	0.000
Titular percentage	−0.006	0.007	0.373	0.013	0.007	0.045	−0.005	0.009	0.571	−0.005	0.011	0.640
Employed percentage	0.096	0.026	0.000	0.106	0.026	0.000	0.031	0.034	0.365	0.052	0.034	0.124
Urban percentage	0.029	0.006	0.000	0.019	0.006	0.001	0.010	0.010	0.277	0.006	0.009	0.482
Population (ln)	0.379	0.103	0.000	0.406	0.121	0.001	0.676	0.175	0.000	0.547	0.218	0.012
Forest cover (ln)	−0.002	0.005	0.616	−0.009	0.005	0.057	0.008	0.006	0.169	0.006	0.005	0.167
Border distance (ln)	0.520	0.193	0.007	0.063	0.202	0.754	0.386	0.204	0.059	0.126	0.169	0.457
Road distance (ln)	−0.237	0.085	0.005	−0.220	0.075	0.003	−0.356	0.102	0.001	−0.273	0.072	0.000
θ	0.100			0.100			0.100			0.100		
AIC	18,006.2			23,711.3			18,893.6			25,076.6		
AUC	0.954			0.956			0.951			0.946		
N	252,701			252,701			561,833			561,833		
DV events	2,999			4,797			3,442			5,082		

(*Continued on next page*)

Table 2. Spatial generalized additive model results including all indicators of interest, control variables, and model diagnostics for each spatial resolution *(Continued)*

	Higher neighboring terrain (I)						Lower neighboring terrain (II)					
	Insurgent event predictors (Model Ia)			Government event predictors (Model Ib)			Insurgent event predictors (Model IIa)			Government event predictors (Model IIb)		
	Est.	SE	*p*	Est.	SE	*p*	Est.	SE	*p*	Est.	SE	*p*
50 km^2 spatial resolution												
(Intercept)	−2.853	2.603	0.273	−9.052	2.243	0.000	−12.145	2.756	0.000	−7.895	2.462	0.001
Spatial lag insurgent events	0.273	0.076	0.000	***0.039***	***0.064***	***0.540***	0.292	0.096	0.002	***−0.071***	***0.067***	***0.291***
Spatial lag government events	***0.050***	***0.034***	***0.142***	0.218	0.027	0.000	***0.032***	***0.046***	***0.495***	0.266	0.040	0.000
Titular percentage	−0.050	0.014	0.001	−0.036	0.009	0.000	−0.033	0.015	0.026	0.015	0.010	0.136
Employed percentage	−0.072	0.082	0.377	−0.008	0.061	0.899	0.050	0.081	0.537	0.069	0.061	0.260
Urban percentage	0.042	0.010	0.000	0.021	0.009	0.020	−0.017	0.023	0.447	−0.018	0.017	0.314
Population (ln)	0.978	0.157	0.000	0.473	0.160	0.003	1.847	0.328	0.000	1.422	0.305	0.000
Forest cover (ln)	−0.026	0.012	0.023	0.003	0.012	0.810	0.037	0.014	0.008	0.029	0.015	0.053
Border distance (ln)	−0.734	0.496	0.139	0.611	0.366	0.095	−1.251	0.373	0.001	−1.156	0.370	0.002
Road distance (ln)	−0.118	0.348	0.733	0.197	0.218	0.367	−0.345	0.213	0.106	−0.570	0.170	0.001
θ	0.608			0.300			0.274			0.144		
AIC	10,387.0			12,428.8			3,897.8			5,548.6		
AUC	0.937			0.932			0.925			0.922		
N	18,083			18,083			18,654			18,654		
DV events	5,600			8,161			759			1,700		
Rayons resolution												
(Intercept)	−11.763	2.121	0.000	−11.529	2.244	0.000	−15.587	2.555	0.000	−11.083	2.132	0.000
Spatial lag insurgent events	0.240	0.027	0.000	***0.099***	***0.035***	***0.005***	0.831	0.098	0.000	***0.530***	***0.066***	***0.000***
Spatial lag government events	***0.157***	***0.030***	***0.000***	0.270	0.023	0.000	***0.107***	***0.049***	***0.029***	0.346	0.038	0.000
Titular percentage	0.000	0.008	0.991	0.003	0.007	0.713	−0.013	0.011	0.261	−0.011	0.008	0.181
Employed percentage	0.019	0.019	0.299	0.015	0.018	0.399	−0.050	0.024	0.037	−0.043	0.022	0.056
Urban percentage	0.004	0.004	0.390	0.003	0.004	0.460	0.001	0.005	0.871	−0.001	0.004	0.812
Population (ln)	0.577	0.117	0.000	0.496	0.101	0.000	0.631	0.189	0.001	0.459	0.155	0.003
Forest cover (ln)	0.011	0.011	0.339	0.000	0.009	0.967	0.005	0.010	0.648	0.009	0.009	0.345
Border distance (ln)	−0.230	0.368	0.532	−0.154	0.409	0.707	0.948	0.492	0.054	0.595	0.432	0.168
Road distance (ln)	0.200	0.137	0.146	0.395	0.122	0.001	0.340	0.124	0.006	0.165	0.118	0.161
θ	0.407			0.328			0.125			0.247		
AIC	14,399.8			17,003.8			8,305.51			10,889.7		
AUC	0.921			0.917			0.925			0.927		
N	33,497			33,497			31,478			31,478		
DV events	4,427			6,641			1,983			3,231		

Note: AIC = Akaike information criterion; AUC = area under the receiver–operator characteristics curve; DV = dependent variable violent event count.

profiles are not statistically significant at conventional levels. One reason for a government's inability to reciprocate after insurgent violence is that in low terrain areas, insurgents retreat beyond the range that is captured in our units of analysis. In other words, government reciprocity might not be expected in the immediate vicinity of an insurgent incident.

The possibility that movements of either actor across the operational territory could influence our results, as in the preceding hypothetical scenario, is sound justification for examining our conclusions across alternative spatial resolutions of analysis. Our results in Table 2 show that at 10 km^2 and at 50 km^2 support for the first proposition disappears; insurgent reactions to government violence are no longer statistically significant in high neighboring terrain areas (at $p \leq 0.1$ the 10 km^2 result is noteworthy). Although this exercise calls into question the robustness of a 25 km^2 test of the first proposition, our rejection of the second proposition is consistent across the different spatial resolution aggregations. Because government forces still have statistically insignificant reactions to insurgent violence in low neighboring terrain regions at 10 km^2 and at 50 km^2, we are reassured that our conclusion for this proposition is not heavily biased by the MAUP.

In the bottom panel of Table 2 we present our estimates for rayons. At this spatial resolution each proposition estimate is statistically significant. This difference in model results could be due to the strategic importance of administrative unit borders for both actors. Model IIb shows that for every insurgent event in lower neighboring terrain regions, there is 69 percent more government violence (0.530 increase in log event count). In lower neighboring terrain regions, government events lead to a comparatively small increase in insurgent-led conflict of 11.2 percent (Model IIa; 0.107 increase in log event count). These results strongly support the second proposition, in contrast to our earlier models. Governments appear to have an advantage in regions that do not have high-elevation surrounding rayons. The first proposition, which has tenuous support across grid cell analyses earlier (only the 25 km^2 resolution), is supported for the rayon-scale dynamics of violence. Comparing Models Ia and Ib, insurgent reactive violence is substantially stronger in areas with high neighboring terrain than government responses; a government event is associated with 16.9 percent more insurgent violence (0.157 increase in log event count), whereas an insurgent event correlates with a 10.4 percent increase in government-led conflict events (0.099 increase in log event count). Although each of the estimates is statistically significant, the greater magnitude of insurgent reciprocity in areas with high-elevation terrain nearby supports the first proposition.

Conclusions

Our study complicates any overly simplistic narratives of conflict actor behavior relative to mountainous terrain and also questions several assumptions that researchers make about the contexts within which civil conflict takes place. All of Russia has often been coded as experiencing civil war at a country level due to fighting in the North Caucasus region, a small area relative to the entire country. Our ability to study intrastate armed conflict within the area where the conflict is taking place isolates specific trends that are unobservable at comparatively coarse spatial resolutions but are expected and intuitive. Our finding that operational costs of context might result in mountainous terrain suiting armed insurgents against government forces is conditional on the definition of geographical context; the distances to which either party is expected to travel within units of observation bring us to different conclusions about conflict behavior. Although mountainous terrain might allow nonstate armed forces to organize, train, and supply, this does not necessarily translate into the blow-by-blow advantage for insurgents in areas near and within mountainous regions, as our results for certain spatial resolutions (10 km^2 and 50 km^2) have shown.

Examining whether our conclusions hold for other regions of the world is a promising path for future research. There is strong evidence, though, that alternative definitions of context, which here is operationalized as the spatial resolution of analysis units, will reveal variable effect estimates for conflicts in any region of the world and for most indicators of interest. As a result, researchers should either provide strong justifications for the reasoning that leads them to adopt their preferred units of analysis or provide transparent results for alternative boundaries. In our ongoing work, we also plan to investigate whether reciprocity between government and nonstate armed actors is characterized by varying temporal dimensions of influence.

The inductive style of analysis we carry out—one that probes effect estimates across a range of geographical scales—is the most transparent approach to studying violent conflict using geographical data at spatially disaggregated scales. Although the physical geographical setting for violence between actors in a civil war setting defines operational limitations, we also stress the influence of MAUP issues for the quantitative study of violence. Presenting research audiences with a single universal effect estimate for any dynamic of violence might ignore messy social realities that shape conflict processes place by place and region by region across the world.

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Supplemental Material

Supplemental analysis for this article can be accessed on the publisher's Web site at http://dx.doi.org/10.1080/24694452.2016.1243038. Table S1 presents descriptive statistics for our data sets at alternative spatial resolutions (10 km^2 and 50 km^2). Figure S1 shows the temporal smoothing term for month ID that corresponds with the spatial smoothing term of our main model presented in Figure 7. Table S2 shows estimates for a Poisson functional form of our model of conflict event count outcomes. In Table S3 we present the results for a binary version of the outcome variable in a logistic regression estimate.

Note

1. We adopt the term *rayon* to refer to the county-scale units in the North Caucasus as well as the subnational units in the South Caucasus, which are variously termed in these countries (Georgia = municipality; Armenia = *marz*; and Azerbaijan = rayon).

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