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WarViews: Visualizing and Animating Geographic Data on Civil War

Nils B. Weidmann
ETH Zurich

Doreen Kuse
Dresden University of Technology

In the recent years, the field of conflict research has produced new findings on the relation between conflict and geography. In doing so, new data sets have been created with the help of GIS software. These data sets include variables relevant for the study of conflict with a spatial component. However, the use of geographic data requires specialized software and substantial training and therefore involves high entry costs for researchers and practitioners. This paper introduces the WarViews project whose aim is to create an easy-to-use front end for the exploration of GIS data on conflict. It takes advantage of the recent proliferation of Internet-based geographic software and makes geographic data on conflict available for these tools. With WarViews, geographic data on conflict can be accessed, browsed, and time-animated in a few mouse clicks, using only standard software. As a result, a wider audience can take advantage of the valuable data contained in these databases, for example, as supplementary data for conflict case studies or for classroom demonstrations. We present two versions of WarViews. The static version runs in a web browser and allows the user to switch between different data sets. The dynamic version is based on Google Earth and can time-animate geographic data such that the development over time can be monitored. The WarViews website can be freely accessed at http://www.icr.ethz.ch/research/warviews.

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In the recent years, the quantitative literature on civil wars has produced important insights into the determinants of intra-state violence. Many of these studies are based on the country level and test civil war using country-level correlations (Fearon and Laitin 2003; Collier and Hoeffler 2004). Quantitative studies have been frequently criticized for their failure to capture the internal dynamics of civil war by aggregating at too high of a level. Consider the example of Russia: suppose we are interested in the relation between diamond occurrences and civil war. Russia has both: Huge diamond mines in Siberia, and a civil war in

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Chechnya. If we were to measure both variables at the country level, the example of Russia suggests a relationship between diamonds and conflict. However, with the diamond mines being located far north and the conflict down in the south, it would be difficult to argue that the diamond occurrences have any effect on the civil war. This criticism triggered a new wave of ''disaggregated'' civil war studies; researchers who take this approach try to get to closer to the mechanisms by examining civil war in much finer detail.

Disaggregation can be done in different ways. One approach is a *conceptual* disaggregation, for example, by singling out the groups involved in a conflict: instead of measuring ethnicity with state-level indicators, we can learn a lot more about the relation of ethnicity and conflict by identifying the ethnic groups involved and their political status (Cederman, Girardin, and Wimmer 2006). However, a large number of studies deal with the geographic aspects of civil war; they disaggregate conflict *spatially*. This has largely been motivated by the fact that civil war is mostly restricted to a fraction of a state's territory (Buhaug and Gates 2002; Buhaug and Lujala 2005), leading to the failure of country-level studies to capture the local dynamics of conflict. Thus in order to explain the local determinants of internal wars, we need information about (i) where these conflicts occur and (ii) their local correlates.

To advance this agenda, researchers have created geographic data sets to examine the impact of different factors on civil war. For example, we already have information about the geographic scope of a conflict (Buhaug and Gates 2002) and the precise location of conflict events (Raleigh and Hegre 2005). For the explanatory factors, we know where diamonds and gemstones (Gilmore, Lujala, Gleditsch, and Rod 2005), petroleum fields (Lujala, Ketil Rod, and Thieme 2007), and ethnic groups (Cederman, Ketil Rød, and Weidmann 2007) are located. However, there is an inherent difficulty in the use of geographic data. Geographic data sets typically rely on complex data formats, and the display of these data normally requires some specialized training and software. This limits even rudimentary exploration of these data to a small community of conflict researchers and practitioners.

The WarViews project presented in this paper aims to make geographic data sets on conflict accessible to a wider audience. Although WarViews is not designed for sophisticated *analyses* of geographic data, it provides a simple and easy-to-use interface for the *exploration* of conflict-related geographic data sets. This is beneficial for at least two reasons. First, it lowers the entry costs of using geographic data to researchers, since no specialized software and skills are required. Second, it allows for the examination and discovery of spatio-temporal patterns of conflict. Even sophisticated geographic software is in many cases unable to deal with the temporal dimension present in some spatial data sets—a shortcoming we tried to address with our project.[1] There are two versions of WarViews. The static version runs in a standard web-browser without any additional software. The user can select the geographic region to explore and the layers of information to be displayed. The dynamic version adds a temporal dimension and builds on the freely available Google Earth software, allowing conflicts to be ''replayed'' in order to explore their dynamics both in space and time.

Our project targets an audience interested in the study of internal conflict, but with potentially very diverse methodological backgrounds. First, people trained in quantitative analyses might find WarViews useful because it offers a quick look at the existing geographic data sets on civil war. For example, does a

[1]The ViewConflicts software by Jan Ketil Rød (2003) features time animation of civil wars on a global scale. However, the software has not been publicly released and does not include spatial covariates of conflict.

data set contain the information I need for my project? Using WarViews, this question can be answered without downloading and converting the data set with one's GIS package. Also, WarViews might be interesting for other areas in the social sciences dealing with spatial data. A similar way of portraying spatial information could be useful, for example, for sociologists mapping data on household incomes. In this paper, we include a section describing the technical infrastructure of WarViews, so that other data projects can follow a similar approach. Second, WarViews can serve as a supplement to case study research. Oftentimes, it might be beneficial to see what existing data sets have to say about the spatial context of the conflict under study. Since the data sets displayed in WarViews include a fair amount of detail besides the geographic information, it is possible to track, for example, the emergence and progress of particular rebel groups. Third, WarViews provides an easy-to-use interface for teaching students the dynamics of internal conflict. Even though the main focus of teaching might not be on the geographic aspects of conflict, it will definitely add to the students' understanding when observing, say, the various stages of the Angolan civil war as an animation in Google Earth. Its ease of use should make WarViews a valuable supplement for conflict classes.

This paper is an introduction to the WarViews project, its design and usage. In Section 2, we provide a list of recent conflict-related GIS data sets and describe the information they contain as well as a short review of the research where they have been used. Section 3 briefly describes the core concepts of displaying geographic data over the Internet. Section 4 introduces the two WarViews visualization interfaces, that is, the ''static'' and the ''dynamic'' versions. In Section 5, we illustrate the use of WarViews with an animation of an episode from the First Congo War. As we have stated above, this paper caters to different audiences, and we have sought to compromise between their interests. We recommend our ''How-to'' in Section 4 to all readers as a minimal introduction to WarViews. Readers primarily interested in conflict and geography might also want to focus on Section 2 in order to learn more about the data included. Section 3 is likely to be useful to people with an interest in the technical infrastructure, although we do not go beyond a general discussion of the system and its components. Finally, for teaching purposes, it might be beneficial to consult our example in Section 5. It demonstrates a visualization that we think could also be part of a course on internal conflict.

Geographic Data on Internal Conflict

The disaggregation approach to civil wars is primarily the result of an increasing dissatisfaction with research on civil war aggregated at the national level. Civil war is a substate phenomenon driven by an interaction of local, national and even transnational processes. To adequately test the salience of local determinants, however, we require geographically disaggregated data. A simple example serves to illustrate this. Consider the proposed relationship between natural resource wealth and conflict (de Soysa and Neumayer 2007). A possible mechanism linking the two is as follows: the presence of natural resources weakens state capacity, thus making conflict more likely. However, another possible explanation could be that rebellion occurs in resource-rich countries primarily as a means of getting control over these natural resources. In these cases, we should see that much of the fighting actually occurs around natural resources; in other words, there should be spatial correlation between resources and fighting. Testing this latter relationship clearly requires geographically disaggregated data on natural resources and the location of violent confrontations in a country.

We can roughly distinguish between three types of data required for a geographically disaggregated analysis of conflict. Data sets of the first type deal with the location of natural resources and can be used to study the conflict-inducing effect. A second type of data examines in detail the actors in a conflict, such as rebels or ethnic groups. Internal challengers to a government are almost by definition geographically restricted, which makes the collection of data about actors and resources below the national level necessary. However, disaggregation also requires data about the dependent variable—conflict—thus motivating the collection of a third type of disaggregated data. Rather than treating violence as a phenomenon affecting a country as a whole, we strive to know which regions are affected by violence, or better yet, the precise location of conflict events. The following paragraphs briefly describe geographic data set of the three types, all of which can be explored with the WarViews visualization tool.

Data Sets on Resources

Geographic data sets on resources have been used to test relationships about the access of conflict groups to resources, or about conflict proximity to these resource occurrences. Questions of this kind were inspired by the recent contention that rebellion is a business. The expectation here is that if rebellion is about the access to, and the control of, natural resources, we should observe the groups in control of these resources be more conflict-prone. By the same token, conflict events should be more likely to occur in proximity to these occurrences. Two geographic data sets have been created to enable such analyses, namely PETRODATA, covering hydrocarbons, and DIADATA, listing diamond deposits.

Hydrocarbons: PETRODATA

PETRODATA (Lujala et al. 2007) includes the locations of hydrocarbons (oil, gas and condensates) for the entire globe, covering 1946–2003. Both onshore and offshore fields are listed, along with the type of reserve. The data set also includes temporal information for each record, namely the year of discovery and production volume. Whilst creating PETRODATA, an additional GIS layer of pipelines was coded. That data set includes the pipeline name, type (oil, gas or products pipeline) and start/end locations of the pipelines of the world. These data are not part of the official PETRODATA release, but was nevertheless included in WarViews to provide a more comprehensive picture of oil transportation networks.

Diamonds: DIADATA

The literature makes frequent references to diamonds as facilitators of conflict (Lujala, Gleditsch, and Gilmore 2005). This is primarily related to the fact that alluvial diamonds are an easily lootable resource and therefore an obvious source of funding for a rebel group. DIADATA (Gilmore et al. 2005) comprises a global list of diamond deposits, distinguishing between primary and secondary diamonds (for details, see the DIADATA codebook). Like PETRODATA, the data set also lists the year of discovery and the first year of production, if available. For all other kinds of gemstones, a separate data set is available.

Data Sets on Actors

Spatial data on the actors in a conflict have been collected to assess the impact of geography on the conflict propensity of particular groups. Once we know roughly where groups settle, we can examine, for example, the influence of state control in remote regions, or the role of trans-border support for the group.

Ethnic Groups: GREG

The ''Geo-Referencing of Ethnic Groups'' (GREG) data set (Cederman et al. 2007) is a worldwide ethnic map. It maps the primary settlement regions of groups as polygons, with up to three groups sharing a given polygon. The data set was created based on the *Atlas Narodov Mira* (Bruk and Apenchenko 1964), a comprehensive volume created by Soviet ethnographers. Combined with other geographic data sets, the GREG data have been used for various studies about ethnic conflict; for example, Buhaug, Cederman, and Ketil Rød (2008) compute population estimates for groups, the distance of groups from the capital, and an indicator for the roughness of terrain where a group lives.

Data Sets on Conflict

As mentioned above, the location of an internal conflict is generally restricted to a portion of the state's territory. Geographic data sets on conflict provide a more detailed account of the geographic arena in which a conflict takes place.

Conflict Polygons

One of the first studies that geographically disaggregates conflict is the one by Buhaug and Gates (2002). Here, a conflict region is approximated by a conflict ''center point'' and its radius, such that the resulting circle encompasses all major events of that conflict. This measure for the conflict area was later refined to a set of polygons (Buhaug and Rød 2006), which we include in the WarViews visualization. For each conflict year, the data set contains a set of one or more polygons approximating the area where the conflict took place.

Conflict Events: Armed Conflict Location and Event Data Set (ACLED)

The recent trend in the creation of conflict data sets has been towards more disaggregation. Whereas Buhaug and Rød (2006) use reports on events to roughly approximate a conflict area polygon, ACLED (Raleigh and Hegre 2005) contains the individual events directly as points. More precisely, ACLED lists reported violent confrontations between rebels and governments troops, along with their geographic coordinates and the day of the event. This way, it is possible to ''replay'' a conflict in space and time, a feature we particularly wanted to include in WarViews.

Further Data Sets on Conflict Events

For the sake of completeness, we would like to mention two other disaggregated data sets. The Political Instability Task Force's *Worldwide Atrocities* data set (Political Instability Task Force, 2008) is a comprehensive collection of violent events against noncombatants, also with geographic coordinates. Due to its focus on one-sided violence, the data set is beyond the present scope of the WarViews project. The *Peacekeeping Operations Locations and Event Data Set* (Dorussen 2007) provides geographically disaggregated data about interventions in civil war. However, it has not been officially released and was therefore not included in WarViews.

Table 1 summarizes the data sets included in WarViews and their geographic and temporal scope. Please note that the WarViews interface is not restricted in terms of the spatial and temporal extent of the data that can be displayed, so the scope of the data sets is defined by the respective data projects. Also, please be aware that the information presented here is subject to change. ACLED is work in progress, and more countries are currently being coded, which should later also be included in WarViews.

Table 1. Summary of the Data Sets Included in WarViews

Data Set	*Content*	*Authors*	*Geographic Scope*	*Temporal Scope*
PETRODATA	Hydrocarbons	Lujala, Päivi/Rød, Jan Ketil/ Thieme, Nadja	Global	1945–2003
DIADATA	Diamonds	Gilmore, Elisabeth/ Gleditsch, Nils Petter/Lujala, Päivi/Rød, Jan Ketil	Global	1946–2003
GREG	Ethnic groups	Weidmann, Nils B./ Rød, Jan Ketil/ Cederman, Lars-Erik	Global	1960s
Conflict polygons	Conflict extent	Buhaug, Halvard/Rød, Jan Ketil	Global	1946–2002
ACLED	Conflict events	Raleigh, Clionadh/ Hegre, Håvard	Uganda, Rwanda, Burundi, Democratic Republic of Congo, Angola, Republic of Congo, Liberia, Sierra Leone, Croatia, Serbia, Macedonia, Kosovo (current coding status, May 2008)	1946–

Displaying GIS Data over the Web

All the spatial data sets on conflict have been, and still are, collected at an enormous effort. Yet their spread within the research community has been limited. A possible explanation for this is the level of specialized skills required for using geographic data. Whereas the presentation and statistical analysis of tabular, nongeographic data is straightforward for many political scientists, the use of geographic data is only beginning to be adopted by the community. Geographic data come in various formats and require at least basic skills in geographic information systems (GIS) software.

The recent years have seen a dramatic increase in the development of web-based geographic applications. Internet applications allow users to easily access geographic data such as street maps, satellite images, hiking trails, and so on. The web is therefore an obvious platform also for disseminating conflict-related geographic data; the aim is to circumvent some of the difficulties with standard GIS systems mentioned above. This is what WarViews has to offer. Before describing the project in detail, let us briefly introduce some standard GIS concepts.

Geographic data typically come in one of two formats: vector or raster data. A raster representation divides the geographic space in equal-sized cells and stores a single value for each cell (for example, the population or the elevation). Vector data on the other hand do not rely on a fixed set of locations, but represent geographic features—for example, cities, rivers, or countries—in a continuous coordinate system. More precisely, there are three typical kinds of vector data: points, lines and polygons. Points are the most basic type. For example, in ACLED we represent the location of an event by a point feature with *x* and *y* coordinates in the respective coordinate system. Line features are essentially series of points in a row. These are, for example, used to represent pipelines in PETRODATA. Lastly, a polygon feature comprises a series of points with an identical start and end point, defining a geographic region. The settlement regions of ethnic groups in GREG are an example of using polygon features with GIS.

Besides geographic information, vector data sets allow for supplementary information to be stored with the features. An attribute table holds a record for each feature. For example, in an attribute table we can store additional information about conflict events such as the actors involved, or the date of the event. Because of its versatility, the vector data representation has been chosen for all data sets currently included in WarViews. In the following, we will therefore focus on the display of vector data over the web.

Web services of geographic data rely on some kind of client-server infrastructure. More precisely, the setup requires a geographic database *server*, which disseminates the data over the web, and a *client* program running on the user's computer, which retrieves the data from the server and displays it. Correspondingly, there are two challenges when developing a system of this kind. First, on the client side, there is the technical infrastructure used for the display. In other words, what software can we employ to download the data and visualize it? On the server side, there is the question of how we can store the data such that (i) they can be transmitted in different formats to different types of client programs and (ii) they can easily be updated—especially important because some data sets (e.g., ACLED) are works in progress and have yet to be completed.

On the server side, we decided to use the free GIS server software Geoserver (Geoserver development team, 2008). Geoserver can read vector data in various formats, including the shapefile format used for many conflict-related GIS data sets. Like almost any GIS, data *storage* and its *presentation* are kept separate so that an update of a data set only requires the new version to be copied to the server, leaving the presentation definition untouched. Furthermore, Geoserver can output geographic data in various formats, making it a perfect choice for our purpose. WarViews uses WMS, an open standard for distributing maps over the Internet (Open Geospatial Consortium, 2008). On the client side, we opted for two different solutions, balancing low software requirements on the one hand, and a rich feature set on the other hand. Both client applications can be run from our website (http://www.icr.ethz.ch/research/warviews) and will be described in detail in the next section.

How to Use WarViews

To give consideration to the different user groups and their requirements, two WarViews client applications are available: a static version that can be used easily inside a web browser without installing additional software, and a dynamic version that requires the prior installation of a freely available client application for geographic data, Google Earth. Both versions of WarViews use a similar display of the data. For example, conflict data are displayed in red (red polygons are the conflict zones, red dots are conflict events from ACLED). Please refer to the WarViews website for a detailed legend of how a particular type of data is displayed. We chose not to include a legend here, since we might want to change the visualization at a later stage, making the information in this article inaccurate.

Static Version

Using the static version of WarViews, the user can get a general impression of the data sets and their content. The data are displayed in a standard web browser window.[2] The map display provides some simple controls. Zooming and panning can be done with the view control, (1) in Figure 1. Additionally, all the

[2]The static version builds upon the free web mapping library OpenLayers (OpenLayers development team, 2008).

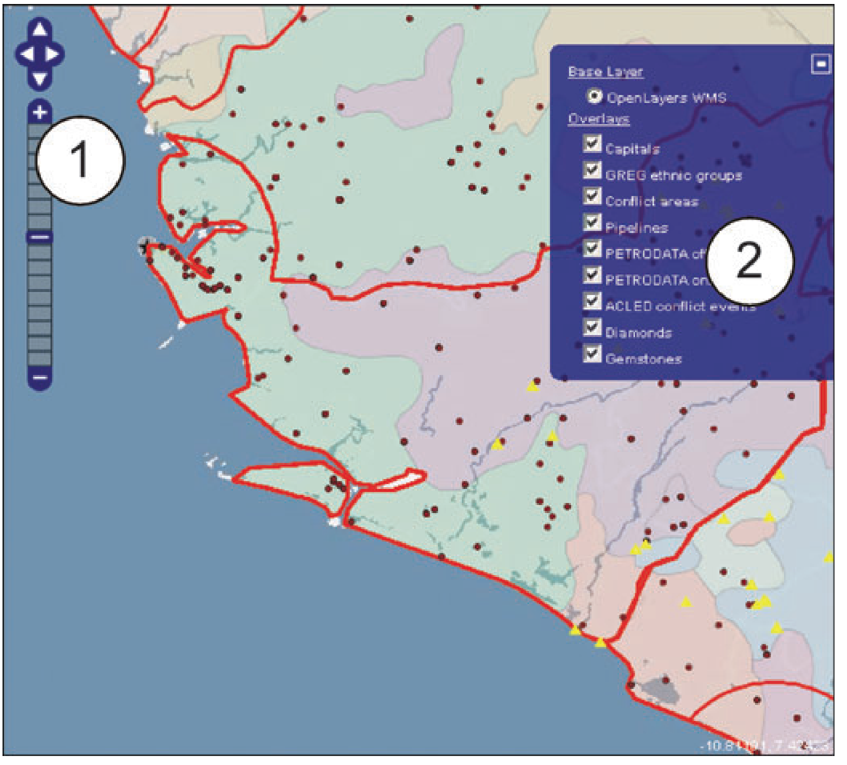


Fig. 1. Screenshot of the WarViews static version. The area to be viewed and the zoom level are set using the view control (1). Data layers can be switched on or off with the layer control (2) that opens after clicking on the top right "+" sign on the map

other data sets can be switched on and off separately in a menu that opens after a click on the blue plus-sign in the upper right corner of the map. However, the static version is not able to visualize the time-component of the data sets; this essentially means that all information for all periods is displayed simultaneously, and hence no animation is possible. For that reason, the static version can only provide a crude overview of the geographic data; for more sophisticated animation, the dynamic version is required.

Dynamic Version

In contrast to the static version presented above, the dynamic version of WarViews requires the installation of Google Earth, a "virtual globe" program. It can be downloaded free of charge from Google (http://earth.google.com) and is available for standard operating systems (MS Windows, MacOS, and Linux). When launching the dynamic WarViews version from our website, a configuration file is obtained that will be automatically opened in Google Earth.[3] This configuration file tells Google Earth to load the WarViews data from our server and to add it to the displayed data sets.

Figure 2 shows the different controls in Google Earth needed to adjust the WarViews display. The zoom control (1) allows the user to set the level of observation. Note that whenever a new zoom level is set, Google Earth has to query

[3]Depending on the user's computer environment, it could be required to download the configuration file to the hard disk, and open it in Google Earth.

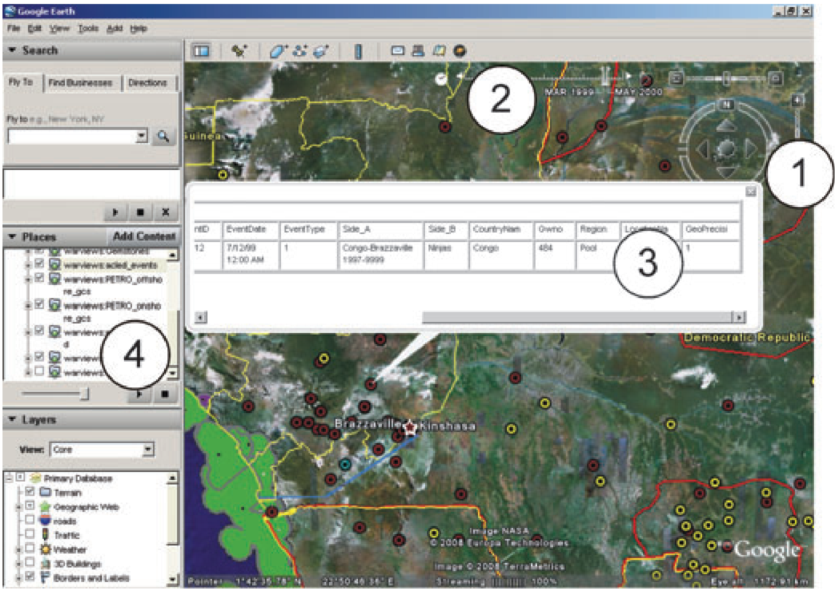


FIG. 2. A screenshot showing the dynamic version of WarViews, which is based on Google Earth. The numbers denote control elements in Google Earth required for adjusting the display of the WarViews data: (1) the zoom control, (2) the time-animation control, (3) the table for supplementary information on geographic data feature (shown for an ACLED conflict event), and (4) the layer visibility control. See text for a detailed description

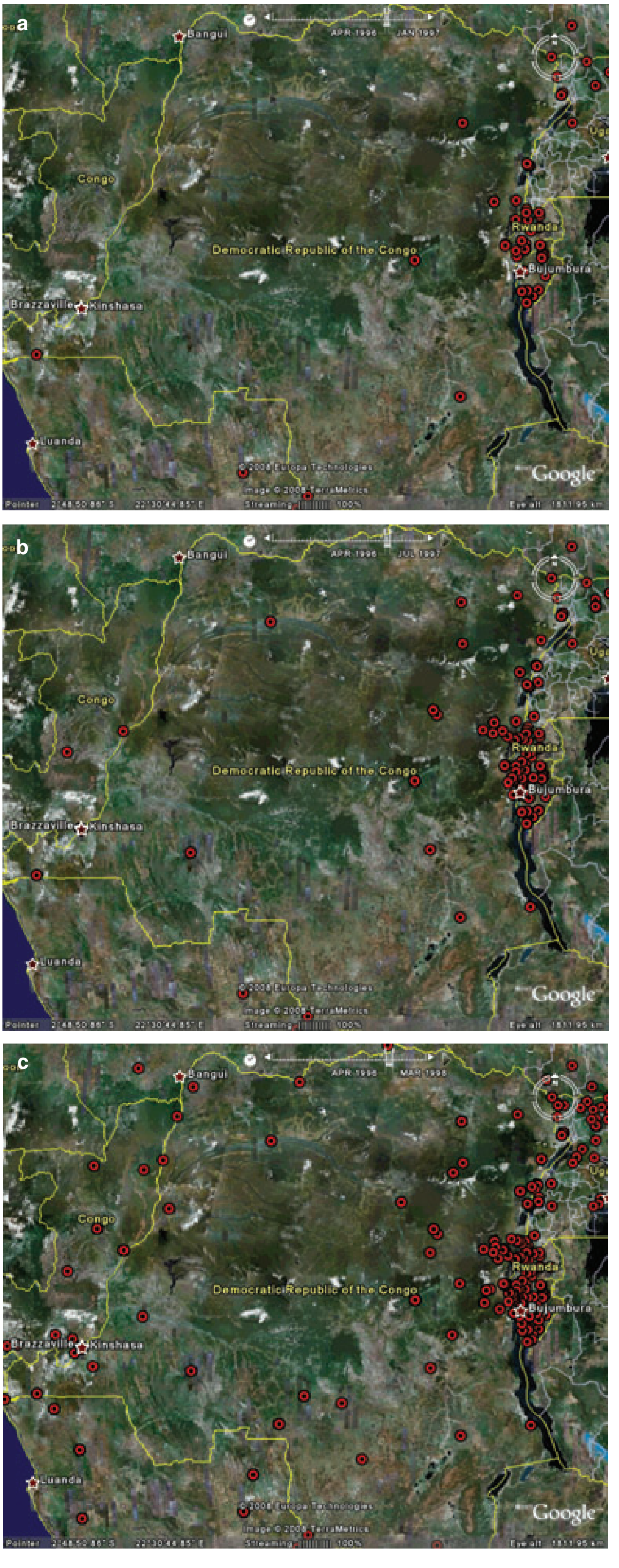
new data from the data server. Depending on the connection speed, this might take a few seconds for the display to update.

The distinctive Google Earth feature the dynamic version takes advantage of is the time-animation control (2). The two conflict data layers in WarViews (conflict polygons and ACLED conflict data) are tagged with temporal information (see above). Google Earth is able to selectively display individual features from these layers that fall within a particular time interval. Using the time-animation control, the user can select a specific time interval and view the conflict data for it, or even animate the temporal display using the ''Play'' button on the right side of the control.[4] While static maps can only visualize snapshots, single events or all the information at once, dynamic maps offer a greater variety of

FIG. 3. The progress of the First Congo War (1996–1997), illustrated in WarViews. The maps show the spread of the conflict over time, originating in the Eastern provinces of the Congo and eventually affecting most parts of the country including the capital, Kinshasa. For the sake of clarity, the only layer shown in the visualization is the conflict events layer. Events are displayed cumulatively, from April 1996 through to three end dates: January 1997, July 1997, and March 1998. Screenshots created using Google Earth.[5] (a) April 1996 – January 1997: conflict in the Congo is mostly limited to the Eastern parts of the country, bordering Rwanda. (b) April 1996 – July 1997: Mobutu's power is declining and his forces are constantly losing ground to the advancing AFDL rebels. Conflict activity spreads further west. (c) April 1996 – March 1998: After the AFDL has taken the capital Kinshasa in late May 1997, almost the entire country is eventually affected by conflict

[4]Google Earth can handle very precise time intervals down to the level of seconds, but since the data displayed in WarViews usually covers more than one decade, the software selects the month as the basic interval.

[5]Satellite imagery is copyright 2008 TerraMetrics, Inc. (http://www.truearth.com/), borders and cities data are copyright 2008 Europa Technologies (http://www.europa-tech.com/). Printed with permission of copyright holders.


a
APR 1996
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Bangui
Congo
Democratic Republic of the Congo
Rwanda
Bujumbura
Brazzaville
Kinshasa
Luanda
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b
APR 1996
JUL 1997
c
APR 1996
MAR 1998

possibilities. Additionally, the time-dependent display leads to a display of fewer objects at once, thus making the visualization more clear.

If the user wants to retrieve additional information on the geographic features displayed in WarViews, she can do so by clicking on the particular feature of interest. This brings up an information table (3) displaying all supplementary information available for a particular feature. For example, for an ACLED conflict event the table displays the parties fighting in a conflict event (see Figure 2).

For areas where there is a lot of data available, one might have to hide data layers that are not of particular interest. This can be done by unticking the respective layer in the layer control window (4); ticking a hidden layer displays it again. In this window, it is also possible to change the order in which layers are displayed; this is done by dragging one layer on top of another one.

By viewing conflict-related data in Google Earth, the user can benefit from many useful functions and features readily provided by this software. There are satellite images at a high resolution for almost any place on the globe; Google Earth also includes many additional data sets, for example with information about streets, borders and populated centers, all of which can aid in exploring the geographic aspects of civil war. Also, the often-claimed relationship between mountainous terrain and conflict (Fearon and Laitin 2003) can be examined in a much more intuitive way. Other information provided in Google Earth, however, should be used with some caution. For example, state boundaries in Google Earth represent the current status of the state system, so there is no time information about territorial changes. However, the most useful feature that distinguishes Google Earth's visualization from other GIS software packages is time-animation. It is now possible to examine the conflict process over time, revealing, amongst other things, the spatial diffusion patterns in civil wars. The next section demonstrates this.

Example: Visualizing the Conflict in the DRC

The features and benefits of the WarViews tool can best be demonstrated with a short example. Using WarViews, we replicate a series of maps that shows the progress of the First Congo War 1996–97. Similar maps were created by Clionadh Raleigh as supplementary material to the ACLED data set (Raleigh 2008). Starting in April 1996, we illustrate three phases of the conflict: a first phase through January 1997, a second one through July 1997 and a third phase through March 1998. In order to be able to observe the diffusion process better, the maps are created cumulatively by displaying the new events in addition to the events from prior phases.

The First Congo War cannot be described independently of other conflicts in the Africa's Great Lakes Region. After the 1994 genocide in Rwanda, the defeat of the Hutu government had created immense Hutu refugee flows into Eastern Congo (at that time, Zaire). The refugee camps were often used as safe havens by militant Hutus to regroup and remilitarize. Zaire's dictator Mobutu Sese Seko did not make a sufficient effort to control the militant refugees, so they repeatedly made forays into Rwanda against the Tutsi population. Rwanda's Tutsi government under Paul Kagame grew increasingly unwilling to tolerate the threat from beyond the border. An uprising of the Banyamulenge, a Tutsi tribe in Eastern Congo, which had been discriminated against by the Congolese government, resulted in a violent conflict between Rwanda-backed Tutsis in Eastern Congo, and Mobutu's forces. Out of the turmoil emerged Laurent Kabila, a former rebel leader, with his new ''Alliance of Democratic Forces for the Liberation of Congo-Zaire'' (AFDL).

The first map in Figure 3(a) clearly shows that in 1996, conflict in the Congo was mostly limited to the Eastern parts of the country, bordering Rwanda. At the same time, conflict activity in Rwanda was high, and the spread of conflict into Zaire is a prime example of the contagion of civil war across state borders (Salehyan and Gleditsch 2006; Gleditsch 2007). With covert support from the Rwandan and Ugandan governments, the AFDL fought hard against Mobutu's forces. In the face of an economic downturn, Mobutu's power was declining and his forces were constantly losing ground to the advancing AFDL rebels. This is clearly visible in Figure 3(b), where conflict starts to spread from the Eastern provinces to the rest of the country. After Kabila had taken the capital in late May 1997, almost the entire country was eventually affected by conflict (Figure 3(c)), mostly along a northern and a southern route of the AFDL towards the capital.

The visualization of the First Congo War presented can be replicated using the dynamic version of WarViews by setting the displayed time period to the desired intervals. An even better understanding of the diffusion process is gained by starting Google Earth's animation feature. It is useful to set a short time interval (e.g., six months) before starting the animation, so the changes become more obvious.

Conclusion

There exist many geographic data sets on conflict, yet few people have the necessary software and skills to use them. The WarViews project makes these data sets available to a larger audience by taking advantage of the possibilities modern web technologies for spatial data have to offer. The project's web-based interface requires no additional training or expert knowledge. In fact, it offers new ways of visualization by adding a temporal dimension, a feature that is missing in many standard GIS programs. This way, spatio-temporal patterns of conflict are revealed, which would otherwise be difficult to recognize. Low entry costs such as an easy installation, a simple interface, and no license fees make WarViews an interesting tool for conflict researchers and practitioners. WarViews visualizations can serve as supplements for case studies of conflict, relieving the researcher of the difficulties arising when dealing with geographic data sets. In the classroom, a dynamic WarViews map helps relate written descriptions of civil war to the actual events, thus further deepening the understanding of the broad picture.

The WarViews interface can easily be expanded to include more data sets as they appear. The client-server architecture makes it possible to process various GIS data formats and provides a unified way of accessing them. Future developments will also include the possibility to enter data through the WarViews website. This way, it would be possible for coders to, for example, add conflict events with their spatial information conveniently in a web-browser. At present, WarViews does not have this functionality, because some formatting of the data sets is required prior to publication in WarViews to assure the correct display of the data. However, already at this stage the WarViews project provides a flavor of future technical developments in geographic conflict research. It is our hope that a large audience can benefit from this project, and we welcome feedback and suggestions.

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