DEVELOPING AN ONLINE SOUTH CAROLINA ATLAS OF ENVIRONMENTAL RISKS AND HAZARDS

Sarah E Battersby
battersby@sc.edu

Jerry T Mitchell
mitchejt@mailbox.sc.edu

Susan L Cutter
scutter@sc.edu

Department of Geography
University of South Carolina
Callcott Building
Columbia, SC 29208, USA

Abstract

This paper addresses issues related to the development of an online version of the *South Carolina Atlas of Environmental Risks and Hazards*. The Atlas reviews fifteen types of environmental hazards that threaten the state of South Carolina, such as hurricanes and tornadoes. For each of the hazards, the Atlas documents general information about the hazard and how/when it tends to occur, what you can do in case of occurrence, and a set of maps to explain how the hazard affects the state. Primarily, the Atlas is used for classroom instruction, but it also serves as a general reference to increase the public's understanding of the local environmental hazards. Since the previous version of the Atlas was published in 1999, much of the data provided is sufficiently out of date that it may not overlap with the memory of the students who are the primary users of the Atlas; it is important to have more current data that include the major hazard events with which students, and readers from the general public, are more familiar.

To remedy this situation, we are currently undergoing a complete update and redesign of the Atlas to transfer it from its current CD format, consisting of a set of static PDFs, to an online and interactive format. In its existing form, the Atlas does not provide any straightforward method for updating the document without manual re-creation of all of the materials; since some online map creation can be done dynamically, not only can we update the Atlas, but we can establish protocols for automating future data updates. Migrating to an online format will also allow us to enhance the ways in which information can be delivered to readers. For instance, through the incorporation of animated maps to show change in hazard occurrence over time, descriptive animations to show how hazards are formed, and tools to permit readers to identify attribute values and interact with map layers.

In this paper, we review the processes behind the update and will specifically discuss the technical, methodological, educational, and usability challenges that we are facing to ensure that the Atlas contents meets the needs of our readers and is in a format that permits easy

maintenance and updating. At the time of writing, the Atlas update has not been completed, and this paper discusses conceptual issues in the construction of the Atlas, and the issues that have had to be addressed in our design. By the time of the 2009 ICC meeting, the Atlas update will be complete, and further discussion of the challenges of the process – and their solutions – will be presented.

INTRODUCTION

This paper addresses issues related to the update and redesign of the *South Carolina Atlas of Environmental Risks and Hazards* (Cutter et al. 1999) to convert it to an online format. The *South Carolina Atlas of Environmental Risks and Hazards* ("Atlas") was originally issued in 1999 in a CD format. Ten years later the material presented is out-of-date and the current format of the Atlas does not allow for easy updates without a complete re-creation of all of the original materials. At the time of writing, the South Carolina Center for Geographic Excellence, the Hazards and Vulnerability Research Institute, and the Center for GIS and Remote Sensing at the University of South Carolina are in the midst of a one-year project to update and redesign the Atlas. For the update, we plan to convert the CD atlas to an online and interactive format, add and enhance the existing curriculum materials associated with the atlas, and, most importantly, lay the foundation for automating future updates and permitting expansion of the geographic coverage of the Atlas. The structure for this work is guided by an interest in creating a format that can easily be modified for use by other states or individuals interested in creating similar atlases of environmental risks and hazards. Funding for the update to this project has been received through the National Geographic Education Foundation.

In this paper, we will review the processes that are being undertaken in the update and will specifically discuss some of the technical, methodological, educational, and usability challenges that we are facing in the process. The paper starts with a review of the existing Atlas, its format, purpose, audience, and why the Atlas is in need of an update. Following this we will discuss the benefits, and the challenges, of transitioning the Atlas from CD format to an online format, including our vision for the updated Atlas. Our vision for the updated atlas will be presented in light of results from a focus group of teachers that are currently using the 1999 version of the Atlas in their classroom.

ABOUT THE ATLAS

Learning about the causes, effects, and geographic patterns of hazards is important part of understanding the local environment. A population that is well educated about hazards is critical so that individual can make educated decisions about how to respond to the threat of, or how to react to, different types of hazards. Unfortunately, it is often difficult to obtain comprehensive and quality information about hazards (Thomas et al. 1999). To remedy this situation, the *South Carolina Atlas of Environmental Risks and Hazards* (Cutter et al. 1999) was created and published as a comprehensive resource to be used in K-12 classroom instruction, as well as to serve as a resource for the general public.

The Atlas reviews fifteen types of environmental hazards that threaten the state, such as hurricanes, tornadoes, floods, hazardous materials spills, radioactive releases, earthquakes, and the hazards of everyday life such as vehicle accidents. Each section of the atlas provides a general description of one environmental hazard and offers practical preparedness information. Detailed explanations and extensive maps and graphs illustrate the historical and geographic patterns of hazards that affect the state. Links throughout the atlas enabled readers to consult additional resources, internet sites, and data tables. Young readers, or individuals with reading or vision problems, are also supported by narrative sound files. For more information on this original version of the atlas, it is discussed extensively by Thomas et al. (1999).

PURPOSE OF THE UPDATE AND REDESIGN

We are currently working on the update of the atlas, with final publication planned for late 2009. This update was warranted due to the age of the previous version of the Atlas, revision of the state educational standards, and a desire to expand the reach of the materials. Each of these issues will be discussed in detail in this section with commentary on how the update can address the issues.

Currentness. The earlier version of the atlas is now almost ten years old, with the most current mapped data being from 1997, so virtually all of the maps are now out of date. With a primary audience of 7th and 8th grade students (roughly 12-13 years old), the data provided in the earlier Atlas may not have any overlap with the memory of the students using the atlas – for instance Hurricane Charley in 2004, which caused over $20 million in damage in South Carolina. To update the Atlas to include these current events, we decided that a complete redesign and update was necessary. For teaching purposes, it is important to have more current data that include the major hazard events with which the students are familiar. Transitioning to an online format, as we intend for this update, will permit us to update the Atlas more regularly, and our intention is to automate the update process so that it will be done seamlessly and with minimal need for future oversight of the updates.

Updated educational standards. One of the goals of the Atlas is to serve as a teaching reference, so the Atlas provides standards-based curriculum materials that teachers can use in their classroom. In 2005 South Carolina has updated its standards for social studies and science. Since the standards have been revised, we feel that it is necessary to revise the curriculum materials that come with the Atlas during the update process. Currently the South Carolina Geographic Alliance has dozens of Atlas-based lesson plans available for teachers that can be modified to match the updated Atlas contents with the new standards. In addition, with migration to an online format, we plan to incorporate features for accepting new lesson plans directly from teachers and for posting information on teaching strategies provided by the Atlas users.

Interactivity. All "pages" in the CD version of the Atlas, including the table of contents, maps and graphics, were provided as linked PDFs, with no options for interactivity other than to jump to another page in the atlas using the navigation buttons on the bottom of the PDF page (see Figure 1 for a sample page from the Atlas). Migrating to a web-based platform will permit us to add animated and interactive functionality to the atlas materials, as well as to design better interactive menus for navigating through the Atlas. Animation and interactivity can be built into

the mapped data and the background / descriptive segments of the atlas. We plan to include the following types of new materials in the updated atlas: animated maps to show change in hazard occurrence over time, descriptive animations to show the processes through which hurricanes and tornados are formed, identification tools to help with map interpretation (e.g., the name and attribute values are listed when the user clicks on the county), ability to zoom in and pan around the maps, options to combine multiple types of data or turn data layers on and off, and provide new options to navigate between themes in the atlas.

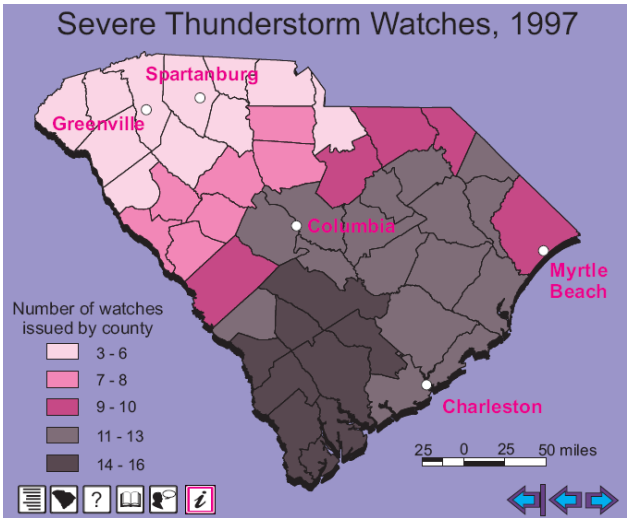

Figure 1. Example map from the South Carolina Atlas of Environmental Hazards (1999)

Distribution. As a CD based product, the audience for the Atlas was restricted by the number of CDs that were printed, and was limited primarily to individuals that are familiar with the South Carolina Geographic Alliance – the main distributor of the Atlas, or the South Carolina Hazards and Vulnerability Institute. Updating the Atlas to use an online distribution method allows us to reach a wider audience, as well as to increase the visibility of the Atlas since the Atlas web page could be found by individuals conducting web searches for information about hazards in the state of South Carolina.

BENEFITS AND CHALLENGES

Research has indicated that static and dynamic visualizations both advance student learning, however they each perform best in different situations, with different types of tasks, and for different audiences (Tversky, Morrison, and Betrancourt 2002; Meyer, Heiser, and Lonn 2001). Digital atlases allow for inclusion of both types of visualization, and provide options for the atlas reader to select the one that is the most effective for the task at hand. Traditional atlases are designed as a collection of static maps, are created with a specific audience in mind, and are often tailored to a hypothetical "average reader" (e.g., middle school students). However, the average reader rarely exists, and atlas topics are often of interest to a wider range of readers than the intended audience. One of the main benefits of an interactive atlas is that the content of the atlas can be customized to meet the cognitive needs of the reader, thus avoiding the need to focus on a specific target audience. By giving some level of control over content, form, and function of

the maps in the atlas, it is possible for the reader to tailor the maps and information to a specific topic of interest, or to meet their educational level.

Online atlases have several advantages over atlases printed on paper or cd/dvd; however simply using an online distribution method does not make the atlas better or more effective than these other methods. One of the primary disadvantages is that the online format requires readers to have internet access. Even though many schools have computers with internet connections available to teachers, not all schools have access to this technology. We feel that this does not tremendously limit the audience for the Atlas, and that teachers can still provide access to Atlas materials either through printing and distributing maps from the Atlas for student use, or through use of the earlier, CD version of the Atlas. We also feel that the limitation of not having internet access will become even more minimal in coming years, so we believe that this disadvantage is far outweighed by the benefits of migrating to an online format.

Specifically from an educational standpoint, research has demonstrated that internet-based lessons have potential for improving teaching and learning, but that teachers are often unprepared to teach effectively with it (Wallace 2004). By migrating to an online format and allowing the Atlas to link to, and take advantage of, the vast resources available on the internet, we add an additional dimension to the Atlas. This can increase the educational potential for the Atlas by allowing readers to expand their knowledge of hazard topics through further exploration (e.g., the Earthquake chapter can link directly to the USGS web site with live updates of recent earthquake activity (USGS 2009)), however it may also increase the complexity of *teaching* with the Atlas since the material is no longer a finite packet of information. Realizing that successful teaching with the internet is made more complex by the vast amount of information that needs to be sifted through by the teacher in advance, and that development of topic-specific activities is time consuming, the updated Atlas is being designed to include prepared curriculum materials that are standards-based and grade-specific. The online format of the Atlas will also allow for teachers to submit their own Atlas-based curriculum materials, and to share their experiences working with the Atlas with other teachers.

TECHNOLOGICAL NEEDS

Since the update to the Atlas demands an online format, we have several technological issues that need to be addressed, as well as a few challenges and questions that still need to be answered. To address these needs and questions, we are currently in the process of conducting several tests to identify the appropriate technological methods for updating the Atlas. First and foremost in our tests is to establish the protocols that will make future updates and expansion of the Atlas to cover new geographic areas or topics as easy as possible.

Attribute data. The updated atlas will rely on data from the Spatial Hazard Events and Losses Database for the United States (SHELDUS). SHELDUS was developed by the Hazards and Vulnerability Research Institute (2009) at the University of South Carolina. The database is a county-level hazard data set for the U.S. for 18 different natural hazard events types such thunderstorms, hurricanes, floods, wildfires, and tornados. For each event the database includes the beginning date, location (county and state), property losses, crop losses, injuries, and fatalities that affected each county. SHELDUS contains more than 450,000 records and spans the

years from 1960 through 2006. Other useful data sources include more state-centered databases that will enable us to update the hazard information through 2007; these databases are part of the holdings of the Hazards and Vulnerability Research Institute.

Spatial data. Since the focus of the Atlas is on hazards in the state of South Carolina, all maps have a base layer consisting of the state's counties. Because counties are present in all of the maps, and because their boundaries are complex, there is no need to generate them on-the-fly. Vector graphics for these boundaries will be re-used for each map. Since many of the maps in the Atlas are choropleth maps using the counties as the enumeration units they only require the collection and symbolization of new attributes from the SHELDUS database. Other maps in the atlas will require the generation of point and line data that will be overlaid on the base layer of county polygons. The SHELDUS database stores latitude and longitude locations for point events (e.g., tornado touchdowns) and for points marking data collection on linear features (e.g., hurricane paths). By translating the projected locations of these point locations to screen coordinates we can convert them into point and line features on the maps. Typically point features are represented by single symbols to represent presence of a feature; however some will show values as proportional symbols. Relevant attributes attached to each point feature in the SHELDUS database will become available to map readers as additional information, should they want it. This additional information is typically data such as the date of an event's occurrence, the name of a named event (e.g., on a hurricane track line), or dollar amount of damage due to the event.

Map design and web development. The SHELDUS database is updated regularly, and we plan to link our base maps with the contents of SHELDUS database to generate up-to-date thematic maps as they are requested by the user. Automating the symbolization of our maps will ensure that the maps are always using the most current version of the data. Since many of the maps will be generated server-side as needed, the download time should be minimized for the end user. As there are several methods for automating map construction and distributing the resulting product to the user, we are currently conducting tests to compare the functionality and practicality of several different methods of automated map development. For the map format, we are considering three different methods for producing and displaying the maps – vector graphics imported into Adobe Flash (Adobe), using scalable vector graphics (SVG), or creating an ArcGIS Server application specific to the Atlas. Each of these methods has benefits and drawbacks. Maps in the Atlas are not reliant on tools for conducting detailed spatial analyses, so many higher-end mapping systems, such as ArcGIS Server are not necessary – but, to the extent where it may provide opportunities for us to add function to the Atlas at a later date – or to use the same map server for more advanced audiences, we are still considering as an alternative to the Flash and SVG software.

With Adobe Flash we have produced a vector base map consisting of individual polygons for each county in the state; each of these polygons is stored independently and the "value" of the polygon can be updated on the fly using ActionScript, the Adobe Flash scripting language, and a connection to the SHELDUS database. For comparison, we are generating a series of test maps using MapView SVG (MapViewSVG 2009) to generate the base maps and then updating the map content with data from the SHELDUS database. At this point in our design process, we have not finalized our decision of which product, Adobe Flash, MapView SVG, or ArcGIS

Server we will use for the online maps; the final decision will be based on ease of use and ability to automate updates, resulting file size and download time, speed of map generation, ability to add and subtract supplemental data layers (e.g., roads, rivers, and major cities) as the user needs them, tools for incorporating interactivity such as for identifying relevant attributes of mapped features, and, most importantly, ability to create a finished product that is easy enough for an elementary school student to use.

In addition to our decisions over the method for map generation, we are trying several methods for importing data from the SHELDUS database, including establishing a direct connection to the database and writing custom queries to create each necessary map, or creating a workflow to produce XML or other types of files containing only the information relevant to the Atlas maps. In the case of XML files instead of using a direct connection to the SHELDUS database, whenever the SHELDUS database is updated a new set of XML files would be generated to replace the old version of the files.

At this point we have not decided on the optimal process for automating our map creation, but tests with map type and software type (Flash vs. SVG vs. ArcGIS Server) and attribute location (SQL database vs. Access database vs. Geodatabase vs. XML or other files created from the SHELDUS database) will guide us in the final decisions for the updated Atlas.

USER-BASED EVALUATION

Prior to the update we have completed an evaluation of the existing Atlas to ensure that the update meets the needs of its primary users. To evaluate the existing Atlas, we worked with a focus group of seven in-service teachers that have been using the Atlas in their classroom. Reviewers were provided a small monetary honorarium when they returned their evaluation. Each member of the focus group was given a CD copy of the original atlas and an instruction document to guide their review. The reviewers were all asked to review the atlas in three main categories: Content, Organization, and Curriculum. All reviews were done independently, and responses were returned by mail.

Since the Atlas is divided into seventeen "chapters," each focusing on a different environmental hazard or risk factor, for the Content portion of the evaluation, each member of the focus group was asked to review four of the chapters, as well as the Introduction chapter, and the supporting chapters (e.g., how to use the atlas, etc.). Each chapter being reviewed consisted of up to four sections: General Information, What You Can Do, Facts About South Carolina, and Maps. Feedback was also solicited on general layout/organization and ability to use the Atlas to support classroom curriculum. In this section, we will review what we learned from the focus group and will discuss how the new version of the Atlas will incorporate this feedback.

Content Evaluation of Existing Atlas

For each chapter in the Atlas, reviewers rated the four sections of the chapter: General Information, What You Can Do, Facts About South Carolina, and Maps. For each of the sections, reviewers were asked whether the information presented is complete and accurate. They rated their agreement with this statement on a Likert scale from 1 to 5, with 1 being

"Disagree" and 5 being "Agree." In addition to indicating their perception of completeness and accuracy of the section, reviewers were asked for written comments for additions or suggestions for improvement.

Completeness and accuracy of information. In response to the statement that "the information presented is complete and accurate," the average response for all chapters was 4.74 / 5; the teachers in the focus group agree that content of the existing Atlas is complete and accurate. The lowest rated chapter, "Winter Hazards" received a score of 4.25 – indicating that the focus group felt that the information presented in the chapter was seen as being complete and accurate. While this quantitative information is beneficial for a cursory evaluation of the content of the Atlas, the qualitative information provided by the focus group was much more useful in determining what parts of the Atlas were most in need of revision in the pending update.

Written feedback from the focus group members on the content of the Atlas was mostly positive and indicated few faults with the content. To organize the constructive feedback, we will discuss comments on the written content and the mapped content of the Atlas separately.

Written content. Each chapter in the Atlas provides general information and background on a specific hazard, a description of what you can do to prepare for the hazard, what to do during a hazard, what to expect post-hazard, and facts about South Carolina related to the specific hazard. Almost all comments on the written content were that the materials were complete, accurate, and sufficient. Suggestions for improvement were restricted to two areas: updating to include what has been learned from recent hazards, for instance, addressing the needs of pets during hazard situations and in evacuations (Edmonds and Cutter 2008), and addition of short summaries geared to younger audiences (2^{nd} to 3^{rd} grade students; ~6-8 years old). Both of these are planned for inclusion in the updated atlas.

Mapped content. The feedback that we received indicates that the mapped content is of high quality and sufficient for describing the spatial patterns of hazards in South Carolina, so most of the feedback received on mapped content was how we could *add* more information to the existing materials. It was mentioned by reviewers that they would like to be able to obtain specific values for counties shown in classed choropleth maps, would like the inclusion of animation (e.g., animating the map showing earthquake centers and the Mercalli Intensity for each earthquake), and would like to control what base data is available on maps (e.g., adding and removing layers for major cities, rivers, and roads). Migrating to an online format for the Atlas will allow us to include the features that have been suggested by our focus group. Our goal is to include tools for identifying point, line, and polygon features on each map to provide names (e.g., county name) and attributes for the feature, such as date of occurrence or total number of events per county.

Post-design evaluation

Throughout the design process, and after the initial design of the Atlas update is complete, our original focus group of teachers will be invited to comment and test the website again prior to the site going live. We will specifically request feedback on the ease of use of the new design, the appropriateness of the reading level and content of the material, the quality of design and ease of use of the maps, whether the tools allowing identification of specific attribute values are

beneficial and easy to use, and how well the Atlas contents are integrated with academic standards. As was done prior to the design process, the feedback will primarily be collected informally an in an unguided setting, with the focus group accessing the Atlas from their home location. In addition, we plan to discuss the Atlas in more detail with the focus group and other teachers interested in the Atlas during the spring and fall workshops that are scheduled annually by the South Carolina Geographic Alliance.

CONCLUSIONS

This paper has discussed some of the issues that are of concern to the updating of an existing digital atlas, the *South Carolina Atlas of Environmental Risks and Hazards,* to an online, interactive atlas. While the translation is between two digital formats, the move to an online format allows greater flexibility in the type of content that can be included, increases the breadth of audience to whom it can be distributed, decreases the cost of distribution, and, most importantly, it can be designed in such a way so that we can ensure that the atlas can be kept current with minimal need for re-creating mapped materials.

The process of designing and implementing the update is guided by a need to ensure that the final product meets the needs of its primary audience of K-12 students and teachers. In order to improve the Atlas for this audience, special care must be taken to ensure that the content and layout support standards-based teaching at these grade levels. Meeting the needs of the range of students in the K-12 audience should also ensure that the content of the Atlas is of a level that is accessible to the general public. To meet the needs of this audience, much of our design work will focus around the evaluation of the previous version of the Atlas that was done by a focus group of seven in-service teachers in the state of South Carolina. Their feedback has been important in our planning for updates to the content and organization of the Atlas.

Since the Atlas is not completed at the time of writing, this paper has only been able to discuss the conceptual issues in the construction of the Atlas, and the questions that we need to address in our design. By the time of the ICCs 2009 meeting in Santiago, we anticipate that our work on the Atlas should be completed and a live version of the Atlas will be available to demonstrate.

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