5C.1 NSSL'S PROTOTYPE ENHANCED SEVERE THUNDERSTORM DATABASE

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1. INTRODUCTION

With the transition to "storm-based" warnings in the United States National Weather Service (NWS) (Ferree et al. 2006), severe local storm forecasts are being issued at increasing temporal and spatial precision. The imminent introduction of new model guidance, new observation platforms, and enhanced applications will allow forecasters to further increase their precision and to introduce uncertainty information (i.e., probabilities) to their severe weather warnings. Verification techniques and the associated severe thunderstorm database, however, remain relatively low-resolution. The existing database also remains largely analog and text-based, despite the increased availability of multimedia and digital resources. To address this emerging gap between the validation data set and modern warning techniques and applications, the National Severe Storms Laboratory (NSSL) conducted the Severe Hazards Analysis and Verification Experiment (SHAVE) in 2006-2007.

Through the use of emerging internet applications, SHAVE-like data sets may be added to multimedia resources (e.g., photographs of damage or video of the severe weather) and Geographic Information Systems (GIS) data sets to form a comprehensive digital database of a severe weather event at much higher resolution than previously available. The NSSL is currently developing a prototype internet-based collaborative portal to manage and host this information.

This paper describes the best methods for creating a dense verification data set as discovered during the SHAVE project, and describes the effort at NSSL to create a database to store such enhanced data sets.

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2. INCREASING REPORT DENSITY: LESSONS LEARNED DURING SHAVE 2006-2007

In order to verify success, efforts to increase severe local storm warning temporal and spatial precision must be concurrent with an increase in density (both temporal and spatial) of the validation data set. The SHAVE experiment was conducted in 2006-2007 to address the need for increased verification data density (Smith et al. 2007).

The SHAVE project found a number of methods to increase density of hail and wind reports, enough to analyze "swaths" of hail and wind damage. The most important principle is to have multiple methods for locating phone numbers in sparsely populated areas. SHAVE used rural county telephone directories, and geo-located databases of residences, businesses, and property tax-payer records.

After identifying a storm of interest, SHAVE students found nearby phone numbers and monitored the nearest radar, calling the phone numbers immediately after passage of the thunderstorm. This required the real-time overlay of radar information on top of mapping software.

Reports of hail occurrence and size were easier to determine using phone calls than information about wind events, according to the SHAVE data collection team. This is because the general public tends to express less confidence in their wind gust estimates, and communication disruptions frequently occurred in the vicinity of major wind events. Students collecting data during SHAVE found that rural residents were more likely to be observant of severe weather conditions (i.e., time and magnitude of the event) than people in urban areas.

The robustness of the SHAVE hail data set is described in Ortega et al. (2006). Equally dense datasets for damaging wind and tornado events were attempted during the 2007 collection period. The SHAVE team found that field surveys are the most effective in compiling a complete wind

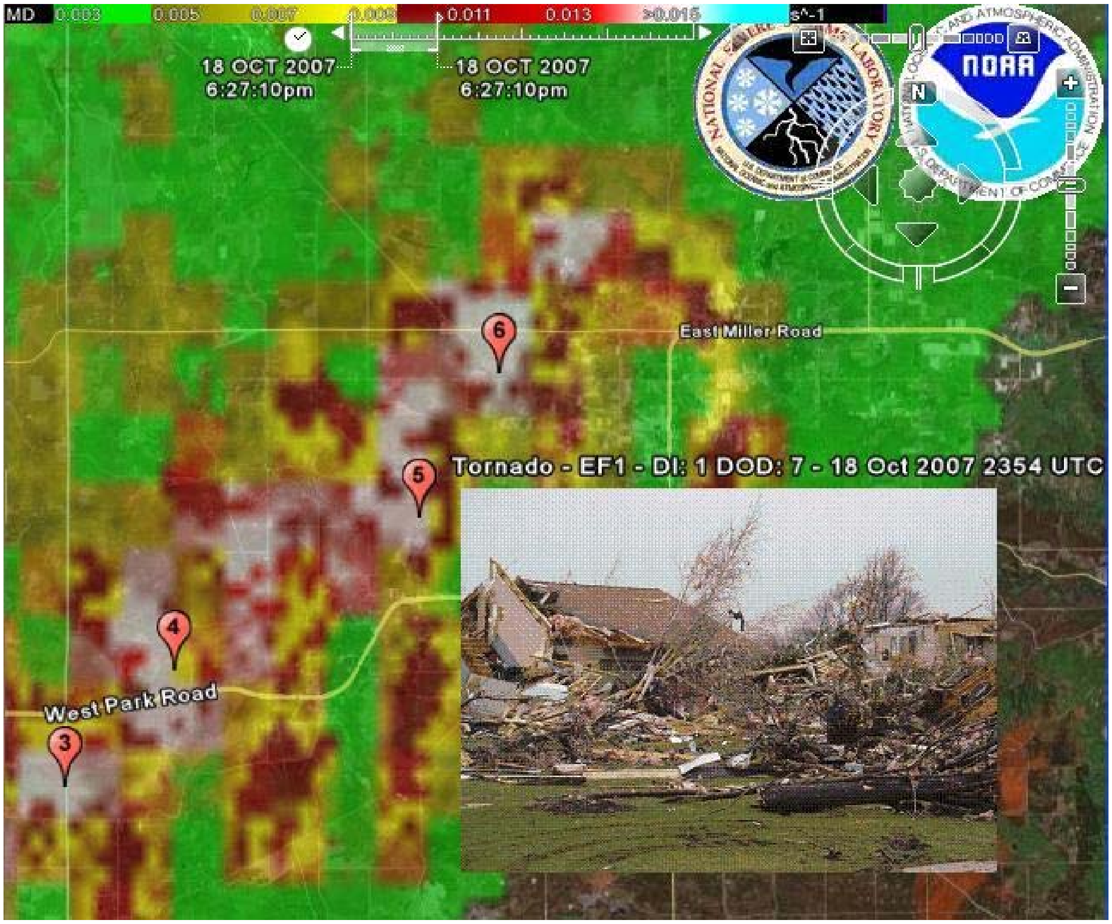

Figure 1. Example of a geo-located photograph and Enhanced Fujita scale characteristics from a damage survey displayed in mapping software. Background image of maximum radar rotational values detected in the lowest 3 km during the passage of the tornado.

damage history. Surveys should be conducted as soon as possible after the event before significant cleanup activities can mask the wind's impact. In addition, media reports monitored via the internet can be used to quickly determine locations of damaging winds.

For complete documentation, field survey teams in association with SHAVE took digital photographs of the damage, took notes about the nature of the damage at each location, and carried a geographic positioning system (GPS). At the conclusion of the survey, the time codes on the photographs and the GPS logs could be synced to geo-reference each photograph. This can facilitate the display and contouring of wind damage on a map (e.g., Fig. 1). These photos can be uploaded from multiple surveyors and displayed in real-time if the surveyors are properly equipped and have digital cell phone coverage.

Data from rural public reports can be combined with reports from more populated areas and storm surveys to create robust event histories for any given storm. These data, including the photos and videos of the storm from the public, media, or from storm surveys, can be compiled on a map background to create "swaths" of damage.

It is important to note that a robust verification data set must include collection in areas not included in a warning, and must also include numerous data points in warning areas already verified. In other words, a verification data set can only be considered complete if it is collected without regard to the warnings issued.

3. ENHANCED DATABASE DESIGN

In addition to the need for a greater density of reports in time and space, there is currently no method in the existing database to store digital data sets. Report density at the levels collected during SHAVE allow “swaths” of hail size, wind speed, or wind damage levels to be contoured and saved as shapefiles. These cannot be currently stored in the severe local storms database.

Multimedia resources, such as digital photographs or video of storm damage, are becoming much more common. These data are frequently “geo-tagged”, or associated with a latitude/longitude pair. Although frequently collected during a storm survey, these data are not routinely stored for future reference. These items can get lost, and even if they are properly maintained, a centralized repository of these assets would be beneficial to people outside the individual office

Storing and interacting with all these data presents a major challenge. The pilot database at NSSL will include hail, wind, and tornado events. Web interfaces will allow the upload/download of point reports, digital photographs, videos, GIS shapefiles, text narratives, and web pages, among other digital data. All information stored in the database will be stored as a "report" that has, at a minimum, a time, latitude, longitude, event type, and description. All digital resources will be stored in a separate table that contains only information about the media object itself (data type, location, description, time, etc.). The reports and digital data resources will be associated through the use of a lookup table that can match multiple reports with each media object (and vice/versa). Storage of other meta data such as the videographer’s name, time of photograph, camera pitch/yaw/zoom, etc. will also be possible.

Each point event (e.g., a hail report) will be stored in a MySQL database and associated with a unique event ID (Fig. 2). Each database entry will also be associated with a unique eXtensible Markup Language (XML) file containing parameters describing the event (e.g., maximum hail size, monetary damage). The database entries can be updated as many times as needed as more associated content is posted.

Each database entry will also contain a link to the next event in the series (if any), allowing reports to be chained together to form a series for a single transitory event such as a tornado, hail swath, or wind damage swath. For example, a single tornado might be associated with 35 data points chained together (each with its own time, latitude, longitude, etc.) based on surveyed damage locations. As storm damage photos are taken by the NWS, storm spotter videos are received, GIS shapefiles are created, and narrative web pages are written, they can be appended to the media index and XML point database entries associated with the event.

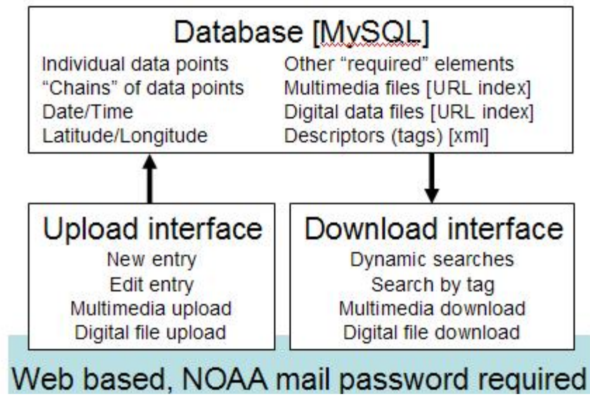

Figure 2. General design of the NSSL enhanced thunderstorm database.

The XML file may also be used to store “tags” associated with the event, facilitating future data research requests. For example, an event may be tagged “high-precipitation supercell”, so that a researcher can later collect all damage survey photographs from tornadoes associated with high-precipitation supercells. The tagging method will also allow a chain of point reports describing a single event to be easily identifiable and dynamically grouped when searching the database (e.g., “Milan to Anson tornado”).

4. TESTING OF THE ENHANCED DATABASE

The database will undergo an informal test and evaluation during the 2008 convective season. First, a series of data points and archived multimedia content (such as damage survey digital photos) for a few well-documented historic events will be uploaded for test and evaluation of the web interfaces.

Once the test on archived cases is complete, a test of a high-impact weather event will be conducted in real-time. It is important the database be capable of collaborative data management, so that multiple users may be uploading and/or editing entries simultaneously. If successful, the database could be easily expanded in the future to include other hazardous weather events (e.g., winter storms, wildfires, and floods), and other digital data sources (such as near-storm analysis grids, audio interviews of survivors, webcam videos, and so on).

5. DISCUSSION

The proposed database design allows highly flexible interaction with the database, opening up numerous future research project possibilities. For example, future researchers might be able to store in the database as XML entries the output parameters from their new near-storm environment analysis grid (such as CAPE and shear). Others might write programs associating the tags describing the storm type (such as "high-precipitation supercell" or "derecho") with radar signatures, near-storm environment parameters, etc., facilitating the development of automated storm-typing algorithms. This searchable and robust verification dataset would become advantageous as "ground truth" when developing new technologies such as Warn on Forecast

Although the pilot project will mostly focus on archival of "real time" events, future projects (potentially led by students) to archive past events will also be possible. For example, digitized photographs of the damage from the 1925 "tri-state" tornado could be archived to the database for all to use. This will allow the permanent preservation of all storm survey information, images of weather events, digital data sources such as shapefiles, research data sets, and even audio or video interviews of witnesses and survivors.

With the advent of the Enhanced Fujita Scale (LaDue and Mahoney 2006), engineers and meteorologists will be continuing to refine the association between wind damage and wind speed estimates. The database design facilitates future reclassification of tornadic wind speeds by allowing the damage indicator (DI) and degree of damage (DOD) to be archived along with a geo-located digital photograph and text description from the survey (as in the example in Fig. 1).

Finally, the extensible design of the database will allow future types of multimedia content and digital data sets that are not yet imagined to be added to the database with relative ease.

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