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GENERATING SEVERE WEATHER WARNINGS FROM TITAN AND SCIT THUNDERSTORM TRACKS.

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1. INTRODUCTION AND BACKGROUND

Severe thunderstorm warnings generated by forecasters in the Australian Bureau of Meteorology (BoM) are produced manually with a text editor. In some offices, hand composed graphical warnings are also produced, complementing the text warnings. Forecasters diagnose storm characteristics by subjectively integrating information from surface analyses, upper air soundings, numerical model output, hourly satellite imagery, 10 minute radar volumes and storm spotter reports. Most of the data used by forecasters is accessed by data browsers on the Australian Integrated Forecaster Workstation (Kelly, J., P. Gigliotti, 1997). Last minute decisions are based on interacting with the radar data on a Silicon Graphics based 3D radar forecaster workstation.

In 1998, the TITAN (Thunderstorm Identification, Tracking, Analysis and Nowcasting, Dixon and Weiner, 1993) algorithms were integrated onto the BoM radar data collection and display forecaster workstations. TITAN diagnoses and tracks storm cells from the raw radar volumes. The BoM is also trialling NSSL's WDSS (Warning Decision Support System), which runs the SCIT (Storm Cell Identification and Tracking, Johnson et al 1998) algorithm. WDSS has been used, like TITAN, to provide extra information, diagnosed from the raw radar data, to help the forecaster make warning decisions.

The ThunderBox software described here is designed to maximize the utility of the Titan and WDSS and other radar processing software by integrating information from them into the forecast production process.

ThunderBox was also used to produce warning products sent to forecast clients during the Sydney 2000 Forecast Demonstration Project (FDP) of the World Weather Research Program and to graphically render processed radar data from participating FDP systems into a common graphics format for presentation on web pages to forecasters in the Sydney forecast office.

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2. FORECAST PRODUCTION PHILOSOPHY

Preliminary analysis of baseline impacts surveys (as yet unpublished) for the World Weather Research Program Sydney 2000 FDP have revealed that some unmet needs for storm warning information. In particular, warning recipients around Sydney expressed a need for :

- more geographic detail than can be easily provided in a text warnings;
- site specific warnings;
- pictures simple enough for people without specialist meteorological training to interpret.

For some clients, an accurate picture of the previous path, extent and severity of storms is just as important or even more important than a forecast for the future location of the storm.

The graphical outputs of ThunderBox are designed to address these needs by providing a deliberately simple cartoon style map showing the observed path of the storms as well as forecast tracks. These are supplemented by meteograms for specific locations which show observed and forecast storm severity.

The approach to forecast production taken by ThunderBox breaks the direct link between the number of decisions a forecaster makes and the number of output products generated. It allows the generation of many tailored products and different representations of forecasts in the same or less time than the forecasters currently take to produce a text warning. It maximizes the re-use of forecast decisions as components of different products. Each product is just a different rendering of the same information in the database of forecaster decisions, so consistency between products is guaranteed.

3. THUNDERBOX DATA DISPLAY AND GRAPHICAL EDITOR.

ThunderBox ingests cell, track and feature data in ASCII text format from multiple radar processing software packages and presents it to the forecaster in an interactive graphical environment.

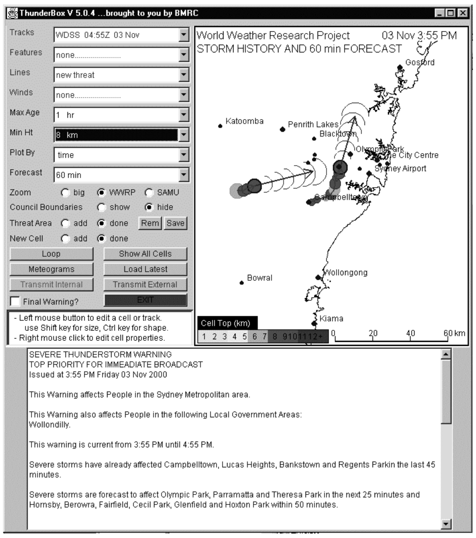

Figure 1
Screen image of the ThunderBox application. This example shows a SCIT based representation of a tornadic storm over western Sydney, Australia on the 3rd Nov 2000.

Figure 1 shows the ThunderBox user interface running on a SCIT representation of a tornadic storm just west of Sydney, Australia on the 3rd Nov 2000. The control panel and context sensitive help are at the top left, the graphical representation of the storm is at top right and the automatically generated warning text is below. The forecaster can graphically edit the representation of the storm using mouse clicks and drags. Alternatively, the storm can be edited via the keyboard on a spreadsheet style data control form (not shown).

The forecaster has direct access to cell and track statistics and feature detections to aid decision making. The storm cell features currently displayed on ThunderBox are mesocyclones, downburst and hail detections, as well as tornado vortex signatures. The forecaster can graphically select which tracks and cells should appear on the finished warning, and change the speed and direction of the storm's forecast motion, as well as the storm size, shape and exact location. These graphical edits form the forecast and warning decisions and are stored as the ThunderBox forecast database. The original data is also stored so that forecaster corrections can be reset to their original values.

The forecast database is rendered as complementary graphical, text and site specific meteogram forecasts or warnings. As the forecaster graphically edits the data, the text and meteogram outputs automatically and immediately update, reflecting the changes the forecaster has made. When editing is complete, the graphical and text products are disseminated to clients. The output products are all consistent with each other because they are just different views of the *same* forecast database, *not* independently generated products.

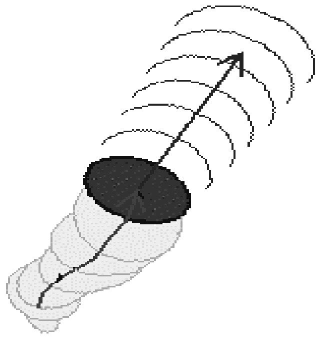

Figure 2
Thunderstorm representation in ThunderBox. The darker filled ellipse with the heavy border represents the current location of the storm cell.

ThunderBox uses some unusual graphics devices to convey information about storms to forecasters and clients (see figure 2.). Storms are represented by tilted ellipses, with only 6 parameters. these are :

- major axis, minor axis, orientation - all directly represented in the graphics;

- storm top height - represented as a color or gray shade in the graphics;

- speed and direction of movement - represented as elliptical arcs drawn in the side of the storm cell towards which it is moving, with spacing between the arcs proportional to storm speed. This representation of movement is intuitive, clear and minimises clutter on the display. It gives the impression of motion on a static display.

Storm cells which are diagnosed by the tracking software as part of the same storm track are linked by arrows in the graphic, again giving the impression of motion on a static display.

Complicated algorithms operating on real data, such as those used for storm tracking do not always perform perfectly. ThunderBox works around these difficulties by giving forecasters access to several tracking algorithms from which they can choose the best performing one on the day to be the basis of the forecast. In its current operational configuration, ThunderBox has real time access to two invocations of TITAN (with thresholds at 35dBZ and 45dBZ) and also to the SCIT tracker in WDSS. These trackers are based on quite different algorithms and tend to have benefits and difficulties in different situations. Rather than attempt perfect automatic tracking, the approach taken by ThunderBox is to use the forecaster's pattern matching and other meteorological skills to fine tune automated guidance. The forecaster's skills are complemented by machine diagnosed cell speed calculations and geographic associations that forecasters do more slowly and sometimes less accurately.

The current version of ThunderBox is written in Java (1.1.8) which makes the code highly portable between computer systems and allows it to run as an applet on some web browsers on some systems. The price paid for this unusual degree of portability is the relatively simple graphics API available under Java 1.x. As support for Java 2 becomes more widespread in the near future, the system will be able to use the more sophisticated graphics API's available with Java 2D, 3D and VisAD.

4. TEXT FORECASTS AND WARNINGS

Computer worded weather forecasts can be produced by systems ranging in complexity from simple template filling techniques known as "shallow" text generators, through to complex artificial intelligence techniques (Driedger et al 2000). Australian severe storm warnings are simple in their lexical structure, as are most severe weather warnings produced around the world. Consequently, it was considered that a shallow, domain specific text generator would be sufficient to produce good quality text forecasts and warnings from the ThunderBox forecast database. Indeed, real examples of ThunderBox text warnings are very similar in style and readability to their manually generated counterparts, but the ThunderBox products contain extra geographic detail that human forecasters do not have sufficient time to include in high pressure warning situations.

The automated generation of forecast text begins with parsing the edited storm cell tracks from ThunderBox's database. Observed and forecast cell locations are compared with a geographic database and lists of local government areas, suburb and site names affected by storms are compiled. These names are included in text phrases along with time information also extracted from the storm cell database. Others phrases in the warning message are simply constructed from information in the storm database or extracted from a small library of standard warning phrases.

The text generator in ThunderBox is simple and robust but produces text of appropriate sophistication for these simple warning messages. The text is always consistent in style and layout and is very clear. The simple and efficient production of text by ThunderBox is also very fast. Indeed it is fast enough to be running continuously and updating as forecasters graphically edit the storm warning. Each graphical edit is immeadiately reflected in the text warning, making it easy to fine tune the text message by making small graphical adjustments.

6. CONCLUSION

The ThunderBox software described here is designed to maximize the utility of Titan, WDSS and other radar processing software by integrating information from them directly into the forecast production process. ThunderBox is unusual in that it is written in Java, making it portable between hardware platforms. It is also unusual in that it is an application of the streamlined forecast production philosophies being recommended by many developers (Ruth 2000), applied to the production of very short lead time warnings.

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