P13B.11 TIFS DEVELOPMENTS INSPIRED BY THE B08 FDP

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1. INTRODUCTION

This paper describes the developments of the Thunderstorm Interactive Forecast System (TIFS) that have been inspired by the participation of TIFS in the World Weather Research Programme (WWRP) Beijing Olympics 2008 (B08) Forecast Demonstration Project (FDP). The history and a description of TIFS is presented first. The paper then briefly describes the FDP environment, forecast process and product requirements, before discussing TIFS developments for the B08 FDP. Finally some future plans are noted.

2. DESCRIPTION AND HISTORY OF TIFS

2.1. *Description of TIFS*

TIFS is an interactive forecast and warning production system. It has a graphical user interface (GUI) through which forecasters can view and edit the output of radar algorithms to produce text and graphical thunderstorm warnings. TIFS is used operationally by the Australian Bureau of Meteorology (Bureau) to create both general warnings for thunderstorms, and also highly detailed thunderstorm nowcasts based on tracking and forecasting individual thunderstorm cells. TIFS can ingest a variety of data, including NWP guidance and lightning strike data, but the most crucial data needed for effective operations are thunderstorm cell detections and forecast tracks such as those provided by the TITAN (Thunderstorm Identification, Tracking, Analysis and Nowcasting) system of Dixon and Werner (1993).

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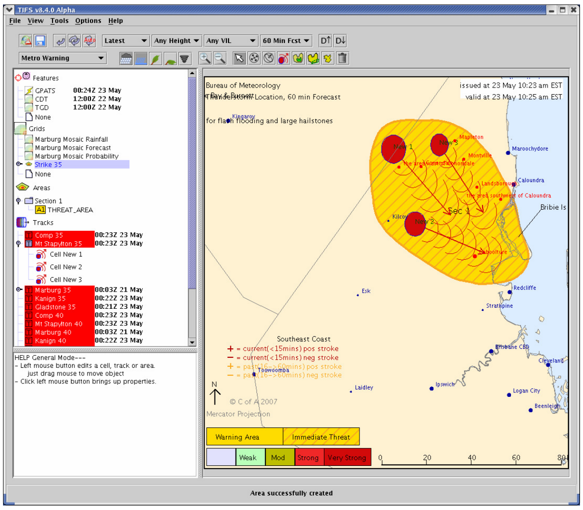

Fig. 1: Example of the TIFS GUI with a set of TITAN cells and forecast tracks, accompanied by a yellow "threat" area.

Figure 1 shows the TIFS GUI and a group of TITAN identified cells and forecast tracks over southeast Queensland, Australia. The yellow area around the cells and tracks is a forecaster drawn "Immediate Threat Area". The tree in the left-hand panel shows the sets of forecast guidance available, from which the forecaster can choose the most appropriate to use as the basis of the Thunderstorm warning. Forecasters can change and move the cell detections and forecast tracks to correct for deficiencies in the automated cell detection and tracking. Corrections are not usually required, but can be important in some situations, such as in the transition phase between ordinary and super cellular structure which is often accompanied by a rapid change in cell direction and speed that tracker systems may take a few radar scans (10 to 20 mins) to pick up.

Once forecaster interaction is complete, TIFS creates graphical and detailed automatically generated text warnings for distribution to the public and specialized users.

2.2. *History*

TIFS was developed in 1999 as a means of visualising the output from nowcasting systems deployed as part of the Sydney Olympics 2000 Forecast Demonstration Project. The systems involved were the auto-nowcaster from the National Center for Atmospheric Research (NCAR), the Warning Decision Support System

(WDSS) from National Severe Storms Laboratory (NSSL), S-Prog (Bureau), CARDS (Environment Canada), GANDOLF (UK) and NIMROD (UK). The aim of the FDP was to demonstrate an impact by these advanced systems on operational weather forecasts produced for the Olympic Games by the Bureau of Meteorology. The motivation for the original TIFS development was to facilitate the understanding of the component FDP systems by forecasters, and to provide an avenue for forecasters to interact with system output to produce new weather warning products. The main strategies employed were to use TIFS as an engine to render output from the FDP systems in a common format, and to provide an interface for forecasters to examine and modify the output from FDP component systems and to create graphical and text based warning products from them.

With the upgrade to the Bureau's weather watch radar infrastructure over 2004 to 2007, TIFS was developed into a fully operational system and is now the main mechanism used to provide severe thunderstorm warnings for most of Australia.

3. THE B08 FDP

3.1. *B08 environment*

The B08 FDP will bring together some of the systems demonstrated during the Sydney Olympics 2000 FDP which have undergone years of refinement and further development, plus some new Nowcast systems. These systems provide a rich source of guidance which could be used by TIFS as the basis for warning products. Several of these produce cell detections and tracks (Hong Kong Observatory's SWIRLS, CARDS, TITAN) and some others describe the threat from convective weather on grids (the Bureau's STEPS, Beijing Auto-nowcaster (BJANC), SWIRLS, NCAR's NIWOT, McGill University's initially developed MAPLE). Further information on the B08 Nowcast Systems is available at http://www.bom.gov.au/bmrc/wefor/projects/b08fdp/info.html.

3.2. *B08 forecast process*

Details of the forecast process to be used during the FDP are still being developed. However experts from each group with a demonstration system will be present for much of the FDP period, to run each system and explain the products to staff from Beijing Meteorological Bureau (BMB), who are providing forecasts for the games. It is likely that some specially trained staff from BMB will act as intermediaries, conveying information from the FDP systems to BMB forecasters. One of the aims of the FDP is to demonstrate an impact on the weather services provided.

3.3. *Product requirements*

The product requirements for TIFS for Beijing are not yet well defined, but there is general agreement that the products generated should integrate information from as many as possible FDP systems, into a meaningful "integrated" product. This should be done in such a way as to give forecasters using the system some appropriate control to oversee the way information from the component systems is selected and used in the forecast process to generate the final warning.

4. TIFS DEVELOPMENTS FOR THE B08 FDP

4.1. *Aims*

One of the key forecast decisions made in each severe weather situation during the Sydney FDP was the choice of which system was most accurately analysing and forecasting the thunderstorm threat. The aim with TIFS during the B08 FDP will be to recognise that all participating systems have some level of forecast skill and to experiment with treating the output of the set of nowcast systems as a "poor man's ensemble" (Ebert 2001). The choice of which system to use as the basis of the nowcast will be replaced with the choice of what blend of systems to use to create the ensemble-based nowcast product.

The probability of being impacted by a particular storm during a given period (say, an hour) is a function of the storm's size and intensity, and can be expected to decrease in time along the storm track as the storm's position and evolution become more uncertain. It is possible to estimate the along-track threat probability of impact for nowcasts at various lead times from prior verification results, for example Ebert et al. (2004) did this using data from the Sydney 2000 FDP.

At the same time, the possible area of impact increases in size due to uncertainties in storm position and evolution. Conceptually, one can "grow" the storm area radially in such a way as to preserve its total impact (i.e., impact probability x area), assuming no net growth or decay of storms. This concept is shown in Fig. 2.

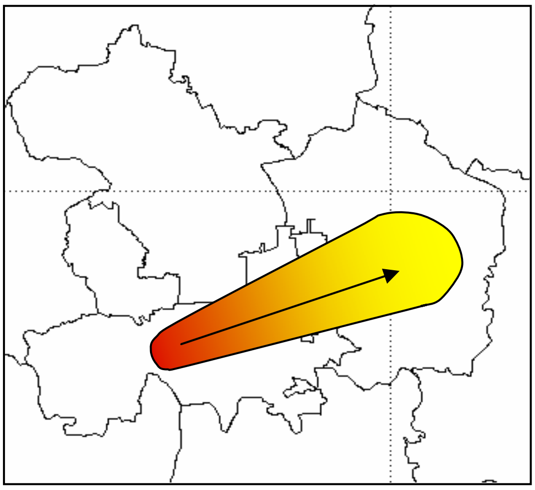

Fig. 2: Conceptual example of possible storm impact probability (colour grading from red for higher to yellow for lower probability).

When mapped to a grid, the composite probability in each grid box is simply the (weighted) average of the probabilities from all of the contributing storms and all of the individual nowcasts.

4.2. *Methodology*

Nowcasts generated from cell tracking nowcast systems (e.g. CARDS, SWIRLS, TITAN and WDSS) are manually or automatically corrected and filtered in TIFS to remove incorrect or insignificant cells using criteria based on Vertical Integrated Liquid (VIL), size, lifetime, height, etc. Forecasters can choose which cells to keep in each of the component nowcasts, and can modify the cell characteristics based on other information. Forecasters can also decide which component nowcasts should be included in the composite product.

The corrected/filtered cells are projected onto a grid. Cell spatial coverage and movement are projected forward in time along the predicted track. The area of each cell is radially expanded over time to represent uncertainty in its position, while the probability of impact is accordingly reduced over time following an assumption of steady state total impact (probability x area). Threat areas are derived from reflectivity nowcasts (MAPLE, BJANC, NIWOT) according to a minimum reflectivity criterion. Similarly, threat areas are derived from rainfall nowcasts (STEPS, SWIRLS, China Academy of Meteorological Research's GRAPES) according to a minimum rainfall criterion. As with the cell tracking systems, the probability of impact is reduced over time and the areal coverage increased.

Finally, a composite threat probability map is computed as the average of the probability maps for all of the component nowcasts.

4.3. *Example products*

Figure 3 shows the chance of being impacted by a storm in three ranges: 10% to 20%, 20% to 50% and greater than 50%. Arrows on the sample product show representative storm cell directions, derived from cell motion vectors (e.g. TITAN) and/ or the fields of motion diagnosed from the reflectivity field by some FDP systems (e.g. STEPS)

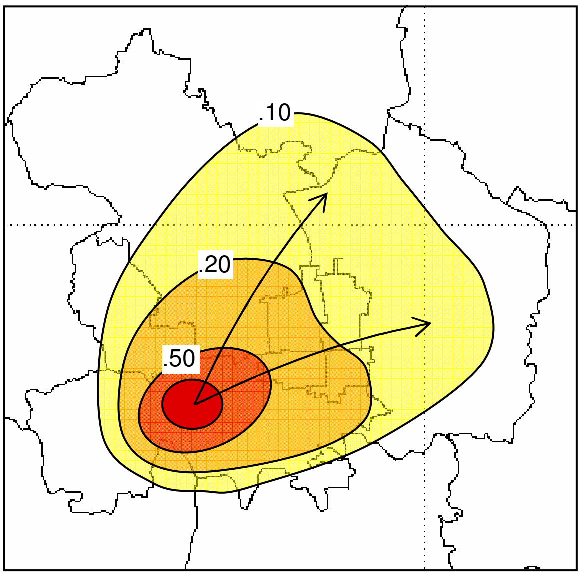

Fig. 3: Conceptual example of possible storm impact probability in 3 ranges 10%-20%, 20%-50%, greater than 50%. Arrows show representative storm cell movement, derived from cell motion vectors or fields of motion diagnosed from reflectivity field grids.

4.4. *Progress to date*

Details of the forecast process and the exact form of the final product are still under development. TIFS has been modified to ingest the XML data format defined for the FDP (Ebert et al. 2007), and has successfully ingested information from some of the FDP systems, including SWIRLS, TITAN and STEPS. Ingestion of nowcasts from other systems is planned over the next few months.

The image in Fig 4 shows the build-up of a "strike probability" graphic in TIFS using the output of two separate tracking systems. In operations these will be built up from a larger number of inputs treated as an ensemble.

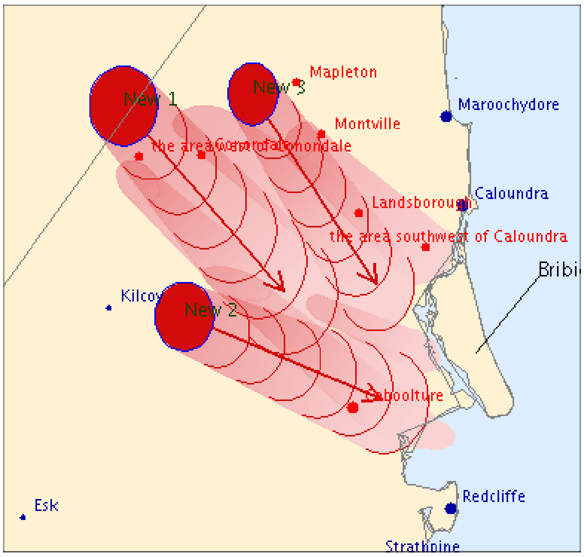

Fig. 4: Example of output from two separate tracking systems being combined to produce a 'strike probability' graphic.

Compare this with the existing TIFS system that uses cells and tracks from only one tracking algorithm against the background of a threat area drawn manually by the forecaster shown in Fig. 5.

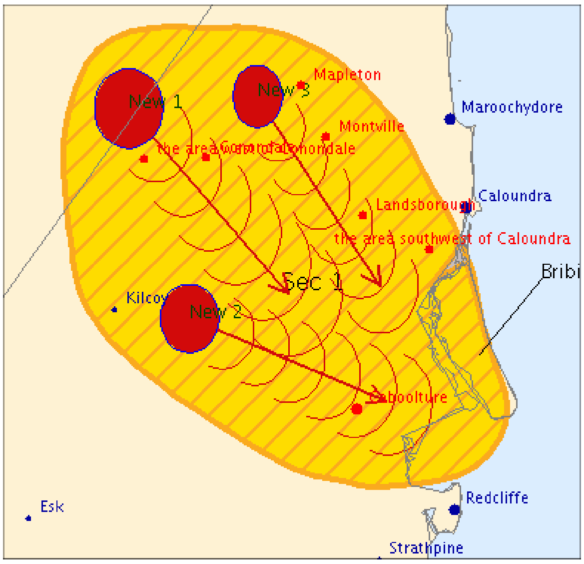

Fig. 5: Same as Fig. 4 except only one tracker system shown, also a manually drawn threat area.

5. FUTURE PLANS

Initially, the development focus for TIFS will be developing the strike probability technique and products for the storm threat in general. Once this is established, development can move to describing the strike probability for each phenomenon that is associated with severe convective weather, including flash floods, hail and damaging wind gusts. Products describing the risk of lightning strike are also envisaged.

Currently the decisions about which cells to warn for are manual, assisted by a facility to filter out cells with low VIL and low top height, and aided by the ability for the forecaster to inspect other cell characteristics diagnosed by radar algorithms. There is scope for improved decision support within the TIFS system to improve the discrimination of severe from non-severe cells. Better support is also needed to assist the forecaster in recognising situations where the automated cell tracking may not be performing well and is in need of correction.

The Bureau plans to apply these developments inspired by the Beijing FDP in future versions of TIFS for Australia.

6. SUMMARY

The opportunity to participate in The Beijing FDP has given the TIFS development team an opportunity to use and compare the approaches and benefits of a range of leading nowcast systems. From the perspective of the TIFS forecast process, these systems are a rich source of guidance for TIFs and provide the opportunity to rethink and develop the way TIFS operates and the range of useful products that can be generated.

7. ACKNOWLEDGEMENTS

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