8.1 THE WORLD WEATHER RESEARCH PROGRAMME (WWRP) SYDNEY 2000 FORECAST DEMONSTRATION PROJECT: OVERVIEW

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1. INTRODUCTION

Given the high potential impact of weather during the S2000 Olympics the World Weather Research Programmme (WWRP) under took its first Forecast Demonstration Project (FDP) in conjunction with the Bureau of Meteorology, Australia to show how operationally tested state-of-the-art nowcast systems could enhance the BOM nowcast service. The goal of S2000 FDP was:

"To demonstrate the capability of modern forecast systems and to quantify the associated benefits in the delivery of a real-time nowcast service".

Emphasis was placed on 0-6 hour nowcasts in an operational framework providing real-time forecasts to users. Radar systems provided the primary observational tool for the shorter duration nowcasts (0-2 h).

The S2000 FDP was conducted over two years. Test phases were conducted during September 1999 and February 2000 with systems remaining in place until the trial conducted over the period 1 September 30 November 2000. This encompassed the S2000 Olympics, the Paralympics. A WMO sponsored S2000 FDP nowcast training workshop was also conducted from 30 October-10 November, 2000. This provided hands on training and lectures from WWRP participants.

2. ENVIRONS AND CLIMATOLOGY

Sydney, the Olympic venues, and associated S2000 observing network, are shown in Fig.1. The Sydney weather is diverse with potential for significant severe weather, lightning, rain and wind events primarily associated with frontal passages and east coast lows. Thunderstorms and severe weather days increase in frequency during spring ranging from an average of 2 per month in September to 6 per month during November.

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Light to moderate SW to NW winds prevail during the morning with sea breezes developing during the afternoon.

An overview of weather during the S2000 FDP is given by Webb et al., (2001) and high impact weather was infrequent. Nevertheless wind shift forecasting, although less dramatic was an important activity for aviation purposes. Severe weather did occur and as described by Sills et al (2001) and Fox et al (2001) a tornadic storm did occur within the WWRP domain.

4. PROJECT COMPONENTS

BOM Observational Network. The addition of a C-Band POLarimetric (CPOL) Doppler/polarimetric radar at Badgery's Ck provided improved "clear-air" radar coverage, and polarimetric monitoring of the Sydney basin. Two additional boundary layer profilers; five portable AWS's (see mesonet in Fig.1) and up to four rawinsonde soundings daily were undertaken at Sydney Airport during the FDP period.

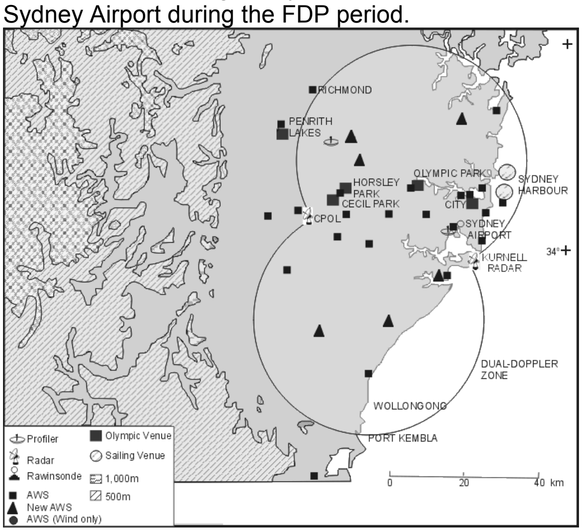

FIG. 1 S2000 FDP sites and observational network.

***CA**nadian **R**adar **D**ecision **S**ystem* (CARDS) 0-1.5 h. The Meteorological Service of Canada CARDS classifies individual radar cells for hail, tornadoes, downbursts, heavy rain etc. and alerts forecasters to potentially severe storms in prioritised order with point forecasts of precipitation to ninety minutes.

***W**arning **D**ecision **S**upport **S**ystem* (WDSS) 0-2 h. The National Severe Storms Laboratory (NSSL) WDSS ingests Doppler weather radar data, lightning data, surface data, and other weather data sources. Using image processing, artificial intelligence and statistical techniques severe weather phenomena (e.g., tornadoes, hail, and high winds) are detected and forecast

Auto-Nowcaster 0- 1 h. The National Center for Atmospheric Research (NCAR) has developed the Auto-Nowcaster expert system that automatically provides time and place specific 0-60 min forecasts of thunderstorms. A unique feature is the ingest of output from a numerical model and its adjoint which retrieves from single Doppler radar data at very high resolution wind and thermal fields in the boundary layer. Thunderstorm initiation, growth and dissipation are forecast.

CPOL Using a "fuzzy " logic technique developed by BMRC a microphysical classification is undertaken of radar detected hydrometeor species including hail.

***S**pectral **PROG**nosis (SPROG)* 0-1 h. Based on an advection of a fractal representation of the radar image a precipitation forecast field is derived.
***G**enerating **A**dvanced **N**owcasts for **D**eployment in **O**perational **L**and-surface **F**lood Forecasts* (GANDOLF) 0-3 h. The Met Office and University of Salford have developed this system for forecasting convective cells. It utilizes a conceptual, life cycle model of convective cells and forecast fields from a mesoscale NWP model.

NIMROD 0-6 h
The MET Office, NIMROD is a fully automatic system employed for precipitation, cloud and visibility forecasts. The basic approach is to use linear extrapolation of present features and to incorporate non linearities of evolution from the NWP model.

Thunderbox The BMRC developed forecast product production system provides web-based display of WWRP forecast products; a basis for interactive modification of forecast products and automated text and web-based WWRP product generation.

5. MODE OF OPERATION

Tuning of algorithms, system development, interfacing to BOM data sources, communications, testing and product merging were important issues. It was recognised by the participants that provision of high resolution and quality controlled radar (initially unavailable in Sydney) was necessary for all the systems. Significant work was devoted to enhancing the quality of existing BOM radar data and using the multiple radars in a network sense. Procedures to improve calibration of all radars were implemented and dual pulse repetition frequency five minute interval volume scans were undertaken with the operational Kurnell Doppler radar.

Final system setup was undertaken starting mid-August 2000 with all algorithm tuning completed by 1 September 2000. After this date tuning of algorithms was 'frozen'.

Each WWRP nowcasting/forecasting system had a representative at the BOM Sydney Office during the S2000 period. The role of these WWRP participants was to "champion" the cause of their particular system within the joint WWRP FDP, and to undertake "training" of BOM "trainers". A rotating WWRP manager was selected from this group to act as the local overall WWRP advocate and interface directly with BOM

6. FORECAST PRODUCTS

Diagnostic and end-to-end user FDP forecasts were provided in real time meeting BOM operational deadlines. The diagnostic FDP products were used by the official BOM forecasters. Outputs from individual WWRP systems were made available on an interactive workstation for forecasters that is described by Bally et al. (2001). This approach enabled static display, meteogram representation and animation of individual WWRP products for forecasters located locally and remotely. This system also provided a WWRP forecast policy and a capability for forecasters to provide queries to the WWRP.

Significant new information was available to forecasters through the WWRP that was automatically generated from the radar data. This information was primarily in the form of forecast precipitation fields and tracks of severe weather features e.g., hail size, downburst location, rotating thunderstorms. Areas of convective initiation, NWP analysis fields based on latest assimilation techniques were also available.

Nowcats were provided directly to end users that included the general public, emergency services, the aviation industry and "Bridge Climb" a private company providing Sydney Harbour Bridge Climbs. Using Thunderbox, WWRP in conjunction with the BOM severe weather forecasters produced new experimental products disseminated by traditional facsimile and web-based approaches. Meteograms for specific venues were produced automatically and "cartoon" type field representations of past and forecast objects were derived. An example of the emergency services web-based product is shown in Fig.2.

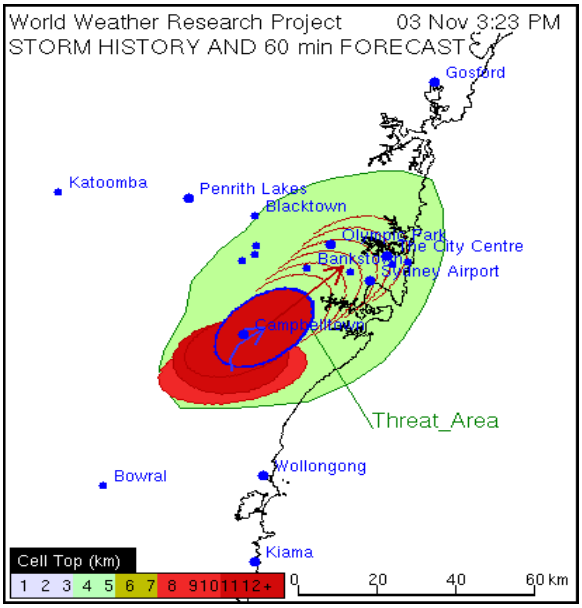

FIG. 2 Example of WWRP/BOM Emergency Services product depicting past and future track with threat area (over next hour) for tornadic storm of 3 November, 2000.

7. VERIFICATION AND IMPACT STUDIES

An international WWRP verification advisory group is assessing the accuracy of WWRP FDP products based on objective measures and subjective forecaster type evaluations, as described by Brown et al. (2001). The verification advisory group will be responsible for neutral evaluation of the FDP products.

A common dataset has been created and supplied to the verification group. Verification is addressing the accuracy and skill of convective cell forecasts; the accuracy of quantitative rainfall prediction; the predictability of point wind speed and direction forecasts; the accuracy of hail size and detection nowcasts and if forecasters improve the quality of the forecasts.

A small WWRP advisory group is considering issues related to the impact of FDP products on users. Information was obtained using surveys, structured and ad hoc interviews, observation and specific user feedback e.g., email feedback from the web-based products. Key questions being addressed include how was the WWRP information used by forecasters to produce better nowcasts and how the improved nowcasts were accessed, used and acted upon by “end users”. Some secondary issues include lessons learnt, how decisions were made in response to hazardous weather events and what agencies were involved and, an evaluation of perceptions of “good” and “bad” forecasts.

Forecaster evaluations although often less objective were considered an essential component of the whole process. Initial results showed forecasters used the WWRP products, the WWRP products increased their confidence in decisions, and a positive interaction occurred with WWRP system champions. Initial opportunities for specialist “end user” use of products were limited but comments were constructive and positive.

8. CONCLUSION

The S2000 FDP was a major undertaking providing unprecedented access to latest nowcasting systems and an evaluation of the end-to-end forecast process. In Sydney it provided forecasters access to the latest science, nowcast systems and procedures previously not available within the BOM. In this sense it provided a clear advance over current practices. For the WWRP participants it was a unique opportunity to share ideas and techniques evaluated in an operational setting. Many algorithms were shown to be readily adaptable and transferable to new locations. Training of forecasters and users was an important issue.

The impact studies demonstrate WWRP products were used by both forecasters and end users with significant societal and potential economic impact. The S2000 FDP was considered a major success. It is influencing on-going development of nowcast systems and procedures as well the manner in which interaction with end-users occurs.

9. ACKNOWLEDGEMENTS

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