P5.4 AN AUTOMATED THUNDERSTORM ALERT SERVICE FOR AIRPORT OPERATIONS

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1. INTRODUCTION

Thunderstorms and the associated weather have a range of impacts on operations at airports that include disruption to air traffic and also to ground operations. Lightning in particular presents a hazard to ground staff and procedures have been developed to ensure safe operations. This includes the provision of alerts when thunderstorms and associated lightning are present in the vicinity of designated airports. Various ground operations cease for the duration of the alert with the result that aircraft docking and associated procedures effectively cease. The flow-on disruption can last for many hours and extend around the country as aircraft cannot be unloaded and refuelled, they cannot leave parking bays and arriving aircraft have no place to park. Manual thunderstorm alerts were prepared in the past but the efficacy was limited because they tended to be conservative and did not provide real-time information on the short-term variations that can occur during periods of thunderstorms. There was a need for better real time information about thunderstorms and associated lightning that enabled better strategic and tactical planning of ground operations by the airlines without compromising safety requirements.

Weather radar and electromagnetic lightning detection systems allow the detection and tracking of thunderstorms and lightning and the utility of these systems for warnings of increasing lightning risk has been shown [Soulage et al., 2004; Murphy and Holle, 2006]. However there are uncertainties with these systems for end-users who may not be familiar with the limitations of each. Experience has shown that end-users often require supporting and consistent evidence from different sources before critical operational decisions are made. There is also a need to present relevant information in a way that can be easily understood by airline personnel. With this in mind an Automated Thunderstorm Alert Service (ATSAS) has been developed that integrates radar data and lightning data and automatically generates end-user products that show the location and movement of thunderstorm cells and the presence of lightning near the airport. The products are updated frequently and can be more easily understood by airline personnel. The airlines in conjunction with airport authorities have developed response procedures that enable them to better manage the disruption and minimise impacts.

In this paper we describe the systems that support the ATSAS, present a case study and discuss operational experiences.

2. RADAR DATA

The Bureau of Meteorology operates a network of conventional, predominately C band, weather radars around the country. These radars mostly provide 10-min low-level surveillance scan data and volumetric scan data and support forecast and warning operations for the public weather, severe weather and aviation weather services and for hydrometeorological operations. In recent years there have been moves to upgrade the radar network and to utilise the radar data more effectively and in a more quantitative way.

In the year 2000 an international Forecast Demonstration Project was conducted in Sydney as part of the weather support for the Sydney Olympic Games (Keenan et al 2003, Joe et al 2004, May etal 2004). The Project demonstrated the capability of modern nowcasting systems to deliver end user benefits and provided a major impetus to the development of a nowcasting system in Australia. In the period since this Project the Bureau has developed a Nowcast Applications Server (NAS) (Bannister 2007) that integrates several radar data processing applications, provides real-time guidance for forecasters and enables the generation of derived products for end users. The Server is located centrally and processes radar data for major locations around the country. Specific components of the system include a radar data server, the Thunderstorm Identification, Tracking, Analysis and Nowcasting (TITAN) application (Dixon and Wiener 1993), the Weather Decision Support System (WDSS) (Eilts 1997), and a quantitative rainfall application known as 'Rainfields', (Seed and Duthie 2007). Storm parameters determined by the applications and information on detected features are then made available to display systems and to other 'downstream' applications that generate end-user products.

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2.1 *The TITAN application*

The TITAN application identifies and tracks ‘storm’ objects or cells in volumetric radar data and calculates associated parameters. In the data processing the polar volumetric radar data are first converted to a Cartesian coordinate system and then passed to the TITAN application, which identifies a ‘storm’ as a three-dimensional contiguous region in space for which the radar reflectivity, the volume and the height exceed defined thresholds. Interpolation of the polar radar data to a Cartesian grid and the identification and tracking of ‘storm’ cells allows the determination of a number of parameters that are then available for ‘downstream’ applications. These include the storm location and size, track details, volume, height, area, maximum reflectivity, VIL and hail metrics.

3. LIGHTNING DATA

At locations where the ATSAS service is provided the Bureau of Meteorology has installed single station Vaisala TSS928 lightning sensors that detect cloud-to-ground (CG) and cloud (IC) lightning that occurs nearby, based on optical, magnetic and electrostatic lightning signals. The CG lightning strikes that occur within approximately 30 NM are grouped into ‘flashes’, assigned to range and azimuth sectors and summed over an ‘aging interval’ of 10 minutes. The nominal range for detection of cloud lightning is 10 NM and the number of cloud flashes is also summed over the ‘aging interval’. The sensor provides reports of detected CG and IC ‘flashes’ that are updated each minute. The reported detection efficiency for CG flashes within 10 NM is 90% and experience has shown this decreases with range and the associated current.

A national lightning detection network is operating in Australia, comprising Lightning Position and Tracking System (LPATS) sensors that use time of arrival technology to identify and locate CG lightning strikes (http://www.gpats.com.au/). The spatial distribution of the sensors for this network is such that the detection efficiency and location accuracy is suitable for the ATSAS requirements only in southeast parts of the country. Also, commercial arrangements associated with this network limit the ability to display the raw lightning data in real-time products for end users. However these data are valuable for validating the ATSAS products and the network is progressively being upgraded so the detection efficiency and location accuracy in remaining parts of the country will gradually improve.

4. ATIFS

The Thunderstorm Interactive Forecast System (TIFS), (Bally 2004), is a graphical user interface that was developed to enable the integration of a number of different data types and to streamline the generation of thunderstorm warning products. Storm parameters generated by the NAS applications can be displayed in the TIFS graphical interface together with data types from other sources. Forecasters can then interact with the guidance and quickly generate a range of text and graphical thunderstorm warning products.

For ATSAS there is a need for a rapid update of information on approaching thunderstorms and associated lightning and an automated version of TIFS was developed for this reason. The ATIFS application takes TITAN storm track information from the NAS and lightning data from the single station TSS928 lightning sensor and automatically generates the graphical ATSAS products at 1-minute intervals. The end-user graphical products include a plan view of the Airport locality that shows the location of thunderstorm cells and the forecast movement out to 30 minutes. Lightning data from the TSS928 lightning sensor is shown in this product assigned to range and azimuth sectors. A meteogram product is also provided and this shows the duration that a storm will be within defined ranges from the airport. The graphical products are made available on a registered user internet web page that the airlines can access. A schematic that illustrates the data flow is shown in Fig 1.

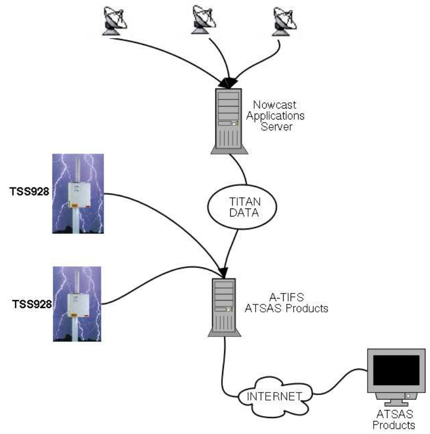

Figure 1. Schematic of data flow for generation of ATSAS products.

5. CASE STUDY

To illustrate the operation of ATSAS Fig.2a, c and e show a sequence of ATSAS products for Melbourne Airport for 19 Jan 2006 at 1535, 1545 and 1645 UTC. This shows storm cells that moved across the airport from the west with forecast positions out to 30 minutes. The storm cells are colour coded according to the VIL. The number of CG flashes detected by the TSS928 lightning sensor is displayed in each range/azimuth sector and the number of cloud flashes is also displayed. As the storms approach the TSS sensor shows CG flashes in the corresponding sectors. The sensor also starts reporting cloud flashes as the storms get closer. For this case the cloud lightning increased rapidly after 1537 UTC and the first CG flash within 5 NM was reported at 1544 UTC. The sensor continued to report CG flashes within 5 NM until 1645 UTC, recalling that a 10 minute 'aging period' is set.

With the combination of radar data and lightning data in the ATSAS product airline personnel can more effectively plan for an interruption to ground operations as the storms approach the airport. Operations will then cease when there is a risk of CG lightning within the 5 NM range ring and restart when the risk clears.

For comparison Figures 2b, 2d and 2f show radar images for the same times as the ATSAS products with the CG lightning 'strikes' detected by the GPATS network overlayed for the same 10 minute period (marked with an X). The number of lightning 'strikes' detected by the GPATS network in the 10 minute period for sectors that correspond to the TSS928 data sectors is also shown. In processing the GPATS data we have followed Biagi et al (2006) and assumed positive-polarity strikes with an estimated peak current less than 15 kA are misclassified cloud strikes and they have been ignored. Comparison of the figures shows consistency between the identified storm cells in the ATSAS product, the radar echoes and the associated lightning clusters.

6. DISCUSSION

The ATSAS service is now operational at Cairns, Brisbane, Sydney and Melbourne Airports and experience has demonstrated its utility. The radar data and lightning data are complementary and integration of these data in the ATSAS product gives end users increased confidence in the integrity of the product and enables more effective use of the information. The products are updated frequently and can be more easily understood by airline personnel. Airlines have developed response procedures to better manage the disruption and minimise the impact to operations.

In an operational environment there is a need for reliable and robust delivery of the products and much effort has been committed to this. This includes the use of merged radar data, where possible, in the TITAN application to minimise the impact of radar system failures at critical times.

A number of uncertainties and limitations remain with the ATSAS products. Storms can develop rapidly and may develop overhead, with little or no lead time provided for the occurrence of lightning. For high based storms the radar reflectivity may be low making the detection and tracking of such storm cells problematic. Lightning can also occur with residual anvil cloud or stratiform cloud and distinct storm cells may not be identified in the radar data.

Further work will be undertaken on the relation between radar signatures and lightning and ways to better classify convective cells according to the risk of lighting. Integration of the GPATS lightning data into the ATSAS product will also provide an increased level of redundancy in the end product and the ability to use these data will be investigated.

7. CONCLUSIONS

In this paper we describe the integrated use of radar data and lightning data to provide automated real-time warnings for thunderstorms and associated lightning for airport ground operations. The ATSAS service is currently operational at Brisbane, Sydney and Melbourne airports and it is proposed the service be extended to other major airports.

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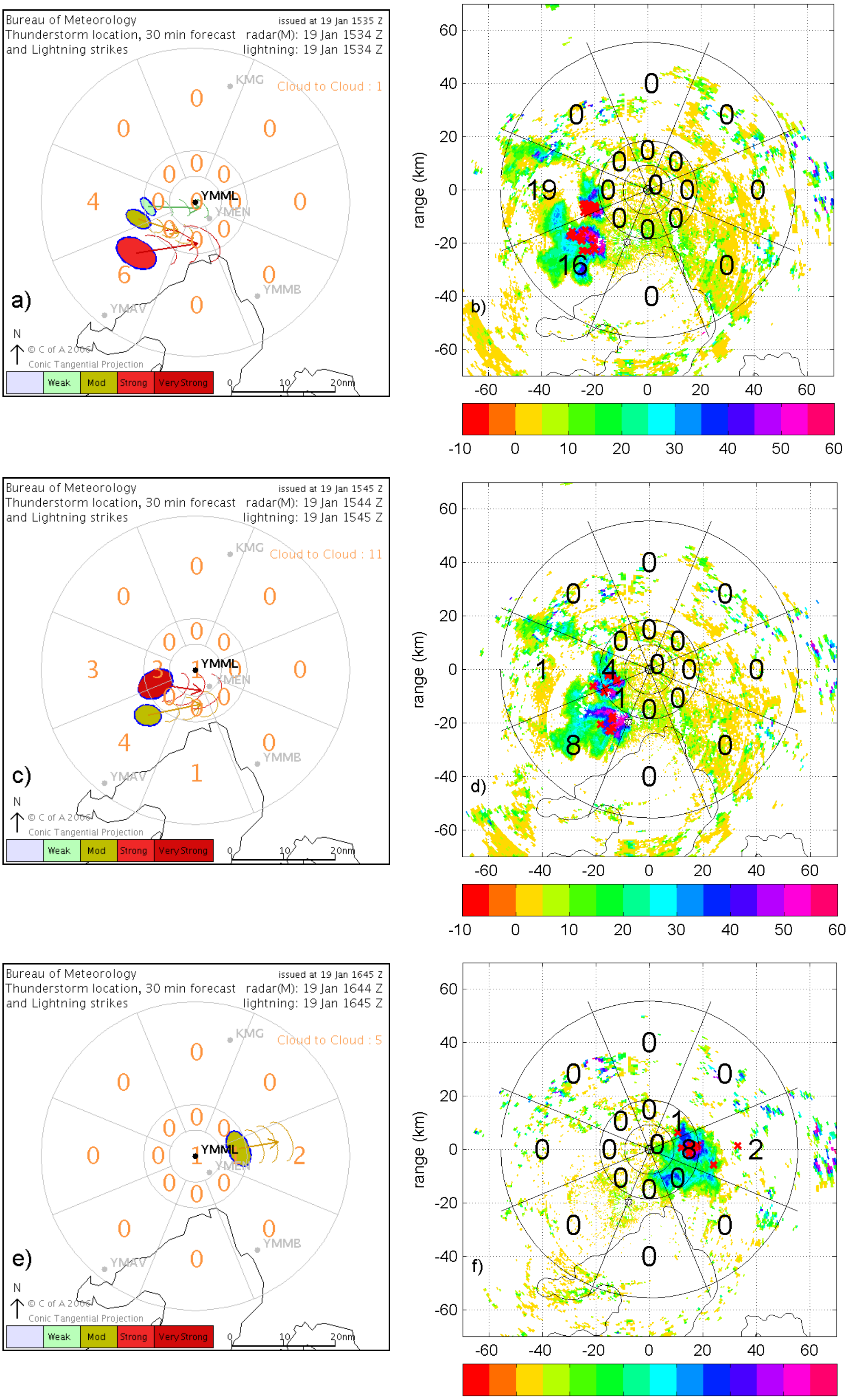

Figure 2. Sequence of ATSAS products for Melbourne Airport for 19 Jan 2006 at (a) 1535, (c) 1545 and (e) 1645 UTC. Corresponding radar images with CG lightning strikes overlayed are shown at (b), (d) and (f) (see text). The colour bar shows the radar reflectivity in dBZ. Range rings at 5, 10 and 30 NM.