P13B.17 DISTRIBUTION OF WEATHER RADAR IMAGERY VIA THE INTERNET AT THE AUSTRALIAN BUREAU OF METEOROLOGY

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1. INTRODUCTION

The Bureau of Meteorology operates a network of over 60 radars spanning most of the Australian continent. Data from each radar is collected up to every 5-10 minutes via a combination of landline and satellite links to its Regional Forecast Centres and headquaters in Melbourne. This paper will describe the recent rationalisation of the communications infrastructure required to effectively collect and redistribute the radar data in real time to the Bureau's Regional Forecast Centres and to its recently commissioned Australian Nowcast System servers.

In recent years, the display of radar imagery on the Bureau's website has been a significant contributor as to why it is regularly rated in the top 10 websites in Australia. Also described is the operational processing of radar data for display and download form the Bureau's web and ftp server system; and the challenges involved in handling high demand periods during severe weather events.

2. RADAR COMMUNICATIONS INFRASTRUCTURE

Figure 1 shows the locations of Australia's weather radars. Every 5-10 minutes raw radar data is generated at these sites.

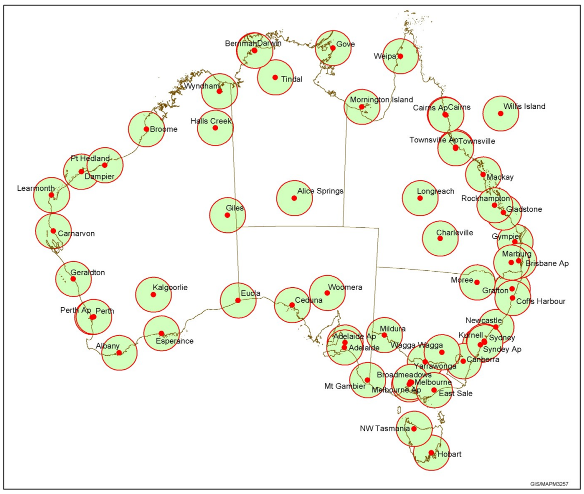

Figure 1: Weather Radar Sites

The data is collected from the radar by the Regional Forecast Centre assigned to the radar. The data is then made available to the specialised forecaster tools at the centre. Figure 2 shows the locations of the Regional Forecast Centres throughout Australia (identified by the red Regional Office icons).

Figure 2: Regional Forecast Centres

All radar data is requested from the regional centres by the Head Office (HO) Radar Data Server in Melbourne. It is at this point that the raw radar data is available to the various clients for processing and/or archiving. (See Section 3). Only the latest scans are provided by the HO Radar Data Server. Therefore, it is the responsibility of clients to request the data in real time, and either store or process the raw data to suit their requirements.

The HO Radar Data Server also acts as a back-up for the regional centres, and thus can retrieve data directly from the radars if required.

3.RADAR DATA TO RADAR PRODUCTS

The Computer Message Switching System (CMSS) is the HO Radar Data Server client responsible for taking the raw radar scans and creating reflectivity images. Figure 3 shows a typical example of a radar reflectivity (Rain Rate) product as seen on the Bureau's public web site.

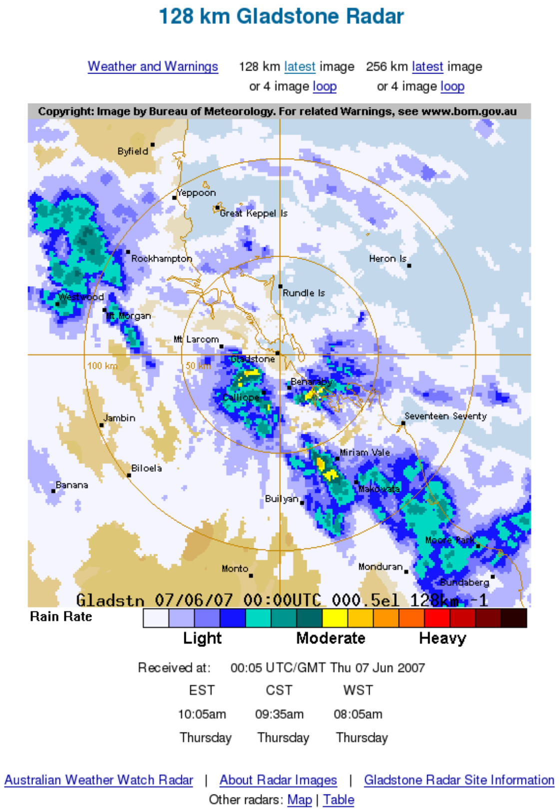

Figure 3: Radar Reflectivity Display on the Bureau Web Site

These images get updated whenever a new radar scan has been retrieved. When this is the case, CMSS runs a script that calls a process to create an image containing the data. The data contains reflectivity values in polar coordinates with respect to the radar location. The process plots the values via gnomonic projection into a 512x512 pixel grid corresponding to a 512km, 256km, 128km or 64km radius region around the radar location. The script can also request that the data be layered over a background map, have range rings added or the legend included on the image. Hence, one or more GIF files are produced which get sent to a various destinations including the Bureau's web and ftp servers. (See Section 4)

As mentioned in the previous section, to make available historical data, a client needs to store the incoming data. HO has two primary Nowcast Servers (NAS): honowcast1 and hownoscast2, which are used to hold product files generated by NAS clients. Refer to Bally (2007).

One of these NAS clients is Rainfields which generates rainfall data products. Refer to Seed(2007). CMSS runs a cronjob every 4 minutes to call a process to create various rainfall images. The particular product, i.e., image data, is extracted from the Rainfields database on the NAS, any required map features are added, and then image is sent out as a PNG of NetCDF file.

Figure 4 shows an example of a 6 hour accumulation rainfall image. The Rainfields/Rainfall products are currently available on the Bureau's intranet, but are due for public release in late 2007.

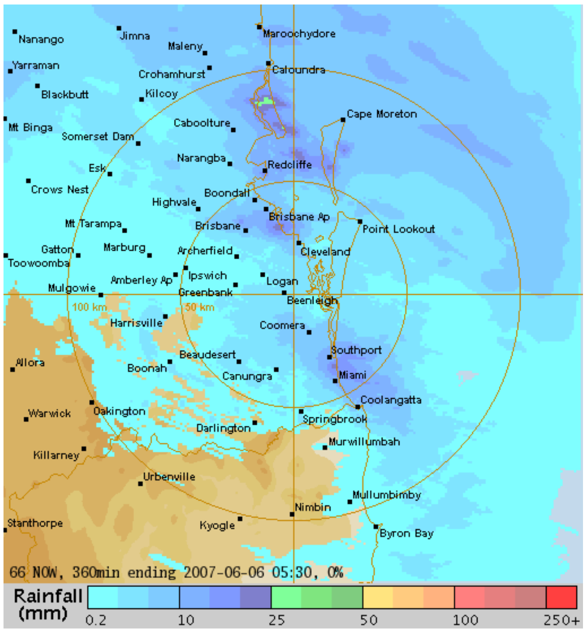

Figure 4: Radar Rainfall Display from the Bureau Intranet

4.RADAR PRODUCTS FOR THE PUBLIC WEBSITE

4.1 Structure of the web pages

At the time of writing, the requirements for the Bureau's external radar web pages were to provide a page of the latest image and a loop of the latest four images for nearly all of the sixty plus radar sites throughout the country at two separate radii of 128km and 256km. (See Figure 3 for an example.) These requirements were based on an initial trial using radar data in the Sydney region on the web during the 2000 Olympics. After its successful use and the positive feedback received, it was decided to proceed with implementation across the other radar sites.

Typically, radars provide a new scan at a frequency of 5 to 10 minutes. However, some radars are used for other duties throughout the course of the day - principally to track weather balloons to provide upper air meteorological wind, temperature and water content data - so they are taken off line for maximum periods of two hours for up to four times a day. These are generally scheduled, but times can vary slightly. Hence, the temporal coverage contains large non-regular gaps. With the additional fact that the regular updating of products using web browsers on the internet is not a stock standard usage (web browsers traditionally being far more designed to request data from servers themselves), the entire environment has thus provided a challenge.

Initially, animated gifs (which are four images combined into one file) were used for looping. But as a new set of four loops must be downloaded every ten minutes, including the three already part of the previous loop, they proved relatively large. With the advent of some Java Script tools, it was quickly decided to split the images into individual files for the loop. This made both the product delivery to the web site, and the subsequent delivery from the web site to the client browser much less bandwidth intensive.

Browsers tend to cache image files with more or less tenacity depending on the browser setting. A combined strategy of using HTML directives to instruct the browser to prevent caching, and the use of distinct image file names were also employed to improve the process

4.2 Development of Radar Services on the Web

More recently, the Radar Network & Doppler Services Upgrade Project (RNDSUP), public weather initiatives and user feedback has driven the upgrade in display of radar products on the Bureau website. The Buckland Park and Mt Stapylton Doppler radar pages have been upgraded to use the new weather display, this includes:

- the approximate geographic latitude and longitude of the position of the cursor on the radar image;
- resetting of the origin to any desired point on the image;
- 64km imagery for the higher spatial resolution Doppler radars;
- the map features, such as roads, railways, river basins, topography, weather forecast districts, lakes and major rivers and range rings split into different layers, with the ability to toggle any particular layer off and on;
- tabbed links to the Radar Reflectivity, Doppler wind and Rainfall images of the current radar site;

Figure 5 shows the Adelaide (Buckland Park) 24 hour rainfall accumulation product on the new display.

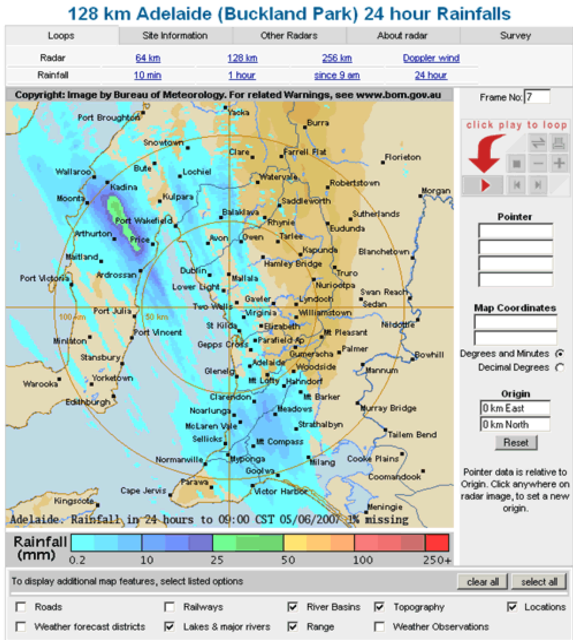

Figure 5: New Weather Display for the Bureau Web Site

The introduction of map features as selectable layers means that we are able to take advantage of image caching for the static features, like topography and map background, and only load the updated “radar” imagery over the top. This delivers some benefits for the Bureau in terms of synching files out to the mirror server (See Section 4.3). These files are smaller in terms of size in comparison to those that were provided in the past that incorporated the map features as part of the radar image.

For example, when comparing a single image in the Mt Stapylton loop at the same time 4:11 UTC June 5 2007

a) GIF image with reflectivity, legend, topography, background, locations and copyright rendered in the GIF, has a file size of 32699 bytes

b) Transparent PNG of reflectivity 7847 bytes, plus

c) transparent locations (includes copyright) layer, PNG 6166 bytes

d) transparent topography layer, PNG 5877 bytes

e) transparent legend layer, PNG 4800 bytes

f) opaque background layer, PNG 2384

Given that the total size of option (b) is 27 kB in comparison to option (a) which is 33 kB the move to a "stacked" radar loop is justified. This however, does not take into account that a loop consists of several radar images. Since a user no longer needs to load a radar GIF image with a rendered background, topography, locations etc. the loop as a whole is smaller in file size. Multiply that across every radar loop and you get significant reductions in download overall.

The default layers are already loaded when the user looks at the first image in the loop, and these layers will have been cached by the browser, so the next time the user goes to visit their favourite radar, they will only download the transparent reflectivity images that form the loop. The same service will essentially be delivered at a lower bandwidth.

Following the upgrade to the Buckland Park and Mt Stapylton radar pages in November 2006, the Bureau surveyed radar users to see if they preferred the new layout. 92% of respondents were pleased with the new layout in the radar loops (See Figure 6). This confirmed that the improvements to the radar interface meet the needs of the majority of our users.

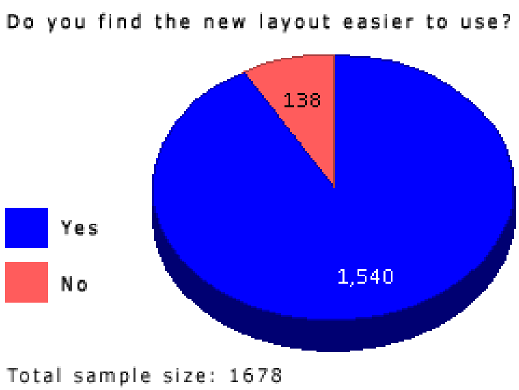

Figure 6: Survey Feedback for the New Radar Weather Display

The available products for the survey were Radar (Reflectivity) and Rainfall. The next release will also provide users with the following options:

- Doppler wind loops for any Doppler radar
- Weather Observations as a layer for any radar.

Examples of these are shown in Figures 7 and 8, respectively.

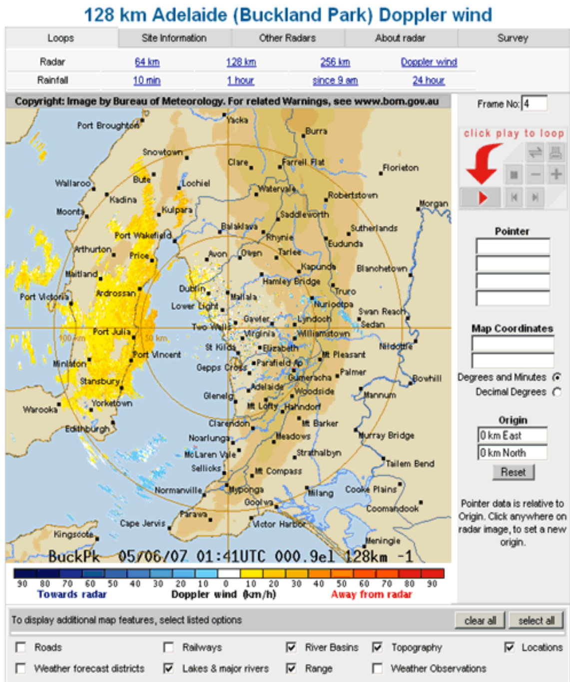

Figure 7: Doppler Wind Display

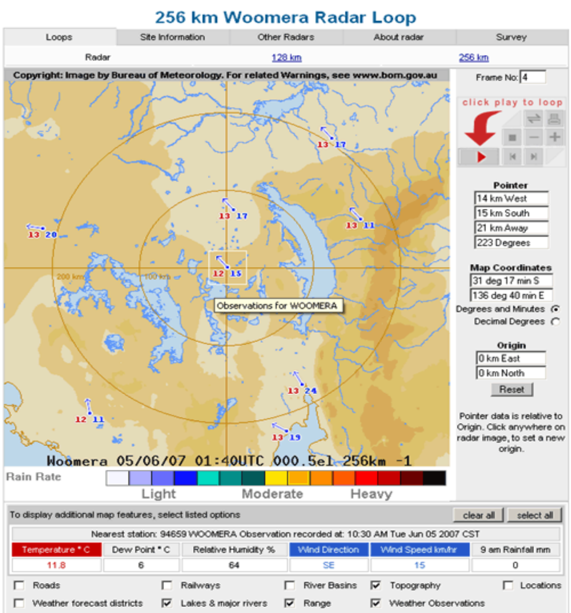

Figure 8: Weather Observations Display

4.3 The hosting web site

As well as designing the web pages to be as light as possible in terms of download but still provide full functionality, the other side of the coin is to host the web site where the radar imagery resides.

As mentioned previously, the radar imagery was implemented on a national scale soon after the 2000 Olympics. As part of the Olympics, an independent second site that mirrored the Olympics component of the main web site was established in case of any disastrous circumstances that befell the main web site. This was hosted using an independent internet service provider (IISP). Initially, the radar site was implemented just as part of the Bureau's main web site (http://www.bom.gov.au/) but after a few days, the demand for the radar imagery meant that the Bureau's internet link was being flooded to the detriment of other traffic vital for the Bureau's day to day forecasting role. An alternate site with the new content of the radar pages was quickly deployed at the IISP (http://mirror.bom.gov.au/weather/radar/) and directives placed in the Bureau's main site diverting all radar associated http requests to the IISP's site with the result that the congestion on the Bureau's main internet link was avoided and the hits on the site taken at the IISP's site.

The volume of the usage of the site at the ISP has grown dramatically since the early days. It has been an excellent trade off for the Bureau in that a set of products that are small in volume themselves (each full radar image being of the order of 30 KB and the new layered images being even smaller), generates such a large download volume that it now contributes to more than half of the total site download volume.

But the popularity of the radar site has also resulted in costing the Bureau significant amounts of money to pay for the associated internet bills. The issue is that the underlying TCP protocol carries out a two way conversation to check if packets have been received intact, etc and the Bureau is charged for (fortunately) the incoming component of the traffic, which whilst small in comparison to the outgoing component, still adds up over such a large volume of downloads. The Bureau is investigating various alternatives to its current environment to keep these costs as low as possible.

4.4 Growth and demand

On average, radar products account for more than 70% of total traffic (in terms of hits) to the Bureau website. The radar growth trend is steeper for the radar products as compared with other content available on the Bureau website (Refer to Figure 9). We have been able to satisfy growing demand through improvements in software and hardware technology and we are looking for further opportunities to improve our content, availability and delivery to users.

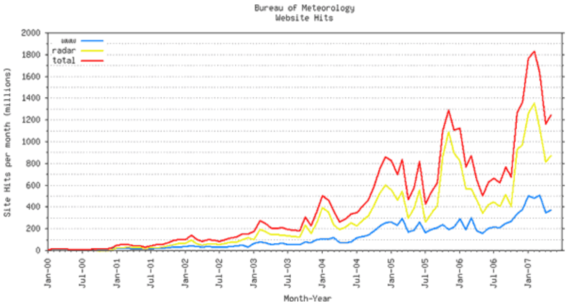

Figure 9: Bureau Web Site Hits 2000-07

With the introduction of the New Weather Display for the Mt Stapylton and Buckland Park radars the Bureau also took the opportunity to ask our users how frequently they check the radar. Figure 10 shows 54% of our users reported that they check the radar more than once a day, 35% reported that they check the radar daily, 9% check the radar once a week, and the remaining 1% check the radar less than once a week. Hence, a large proportion of Bureau users (roughly 89%) visit the radar site at least once a day.

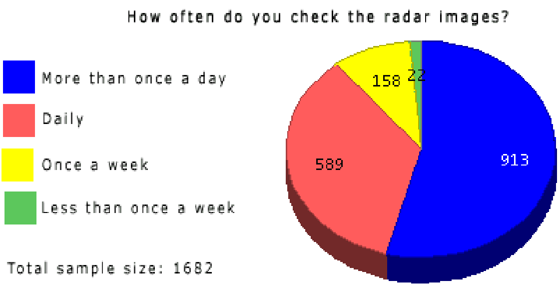

Figure 10: Survey Results for Frequency of Radar Web Page Usage

5. GEOSPATIAL FORMATS AND WEB-SERVICES

The Bureau has recently embarked on building the operational capability for generating and distributing a selection of its products in geospatial formats. This includes making products available as data files, such as ESRI Shapefiles and GML (Geography Markup Language), and via web-services. This will allow GIS users to directly incorporate Bureau data into their GIS systems, and will greatly aid in decision support during times of crisis. The Defence and Disaster Mitigation community have been identified as the primary users of the system, with radar data being a high priority for all.

These web-services include Web Mapping Services (WMS) and Web Feature Services (WFS), both of which are proposed as interoperability standards by the Open Geospatial Community (OGC). These OGC standards will be promoted to ISO standards in time, and are already widely supported by both Open Source and commercial GIS packages.

The Bureau has been running a trial system for the past 18 months which routinely generates ESRI Shapefiles from radar data. The basic method for creating these files involves converting the radar data from polar coordinates to latitudes / longitudes, and then representing this data as either points or polygons in the ESRI Shapefiles. These ESRI Shapefiles are then imported into a spatially extended database (geodatabase), and the data is made available via Web Mapping Services (WMS) and Web Feature Services (WFS). Users can then access the ESRI Shapefiles via FTP, request images of radar data via WMS, or request a GML representation of the data via WFS.

A registered-user trail will commence mid-2007. A feeback will be requested on the various representations.

5. CONCLUSION

As a concluding topic, the navigation between various radar web pages greatly contributes to the success (or otherwise) of the website. With the increasing number of products and the need to include detailed help/information for the accompanying displays, a concerted effort has been made to streamline navigation in a logical and efficient way. Figure 11 shows the latest design of the Weather Radar Help Page. More links, and navigation tools, such as the “breadcrumbs” at the top left corner of the page, and the anchor links (right column) to avoid scrolling long pages, have been widely utilised. Furthermore, the capability to enlarge images in order to view features in greater detail has also been included. Overall, a layering of the complexity has been employed to provide the user a smoother ride through all the information that the Bureau now provides to the public and dedicated users.

6.REFERENCES

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Seed, A., Duthie, E. and Chumchaen, S., Rainfields: A Quantitative Radar Rainfall Estimation System. Preprints, 33rd AMS Conf. Radar Meteorology (Cairns, Australia), 6-10 August 2007, Amer.Meteor.Soc

Figure 11: Weather Watch Radar Help Page on the Bureau Web Site