Doppler radar in the grainbelt - more than just pretty pictures

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Key messages

- New Doppler radars will provide much-needed coverage over the WA grainbelt. Growers, agribusiness and rural communities will be able to access detailed rainfall and wind information to make more-informed decisions.
- Short-term weather prediction across the grainbelt, especially during extreme events, will be significantly improved.
- Consultants and advisors will play a key role in helping growers understand the potential of this new data source.

Aims

There has been a long-standing need to provide radar coverage for the WA grainbelt. While many regions in the eastern states receive Doppler radar coverage, Western Australian coverage has been limited to radars located at Perth (Serpentine) and Kalgoorlie. Importantly, many of our international competitors have broad coverage from Doppler radars.

Technology is becoming increasingly important in supporting a range of agricultural decisions and activities, and the new radars will provide real-time rainfall and wind information to augment ground-based observations. In turn, this new capacity is likely to stimulate improved integration of weather information with agricultural decisions-support systems, particularly as digital connectivity across the agricultural region is improved.

Consultancy reports commissioned by Department of Agriculture and Food WA (DAFWA) in 2014 concluded that expanding the Bureau of Meteorology's (BoM) Doppler radar coverage in the grainbelt would deliver over $100 million benefit to farmers in the region over a 20-year period. It was also estimated that, based on more-timely spray applications alone, the radars could produce a return of over 6:1 for every dollar invested. The State Government has invested $23 million through the Royalties for Regions program to fund installation of three Doppler radar stations.

The new Doppler radars will also enhance the Bureau of Meteorology's weather forecasting and warning systems, which will benefit growers, agribusiness, as well as rural community services.

Method

Doppler radar works by sending pulses of electromagnetic waves, which are reflected back to the radar by objects in their path, such as rainfall or dust. They have an additional ability to measure movement of objects using the Doppler Effect. This was proposed by Christian Doppler in 1842 who showed that the frequency of a wave, perceived by an observer, varies with the motion of the source of the wave relative to the observer. This effect is most commonly noticed with sound waves, an example being the apparent lowering in pitch of an ambulance siren as it passes by. The Doppler Effect is also used in a range of other applications such as police speed guns and measuring the speed of a ball in sport.

The strength of the signal the radar observes is related to the number and size of the raindrops that are illuminated in the radar beam. Changes in the phase of the returned waves are used to derive wave frequency changes, and then radial winds by the Doppler relation.

The Bureau of Meteorology has developed software to convert these signals into an estimate of both rainfall intensity and wind speeds. Rainfall estimates are calibrated in real-time using data from automatic weather stations. The grainbelt of WA now has a dense network of weather stations operated by DAFWA, as well as BoM.

The radar sites will be at Newdegate, South Doodlakine and east of Watheroo, (see Figure 1), with each providing a maximum range of 200km. Newdegate and Doodlakine radars have been installed, with Watheroo to be completed by June 2017. The radar stations will be operated by BoM. Radar images will be available on the BoM website at http://www.bom.gov.au/australia/radar/index.shtml

DAFWA has also expanded its network of Automatic Weather Stations to over 170 to ensure the new Doppler radars are calibrated accurately and to maximise the weather information available to farm businesses.

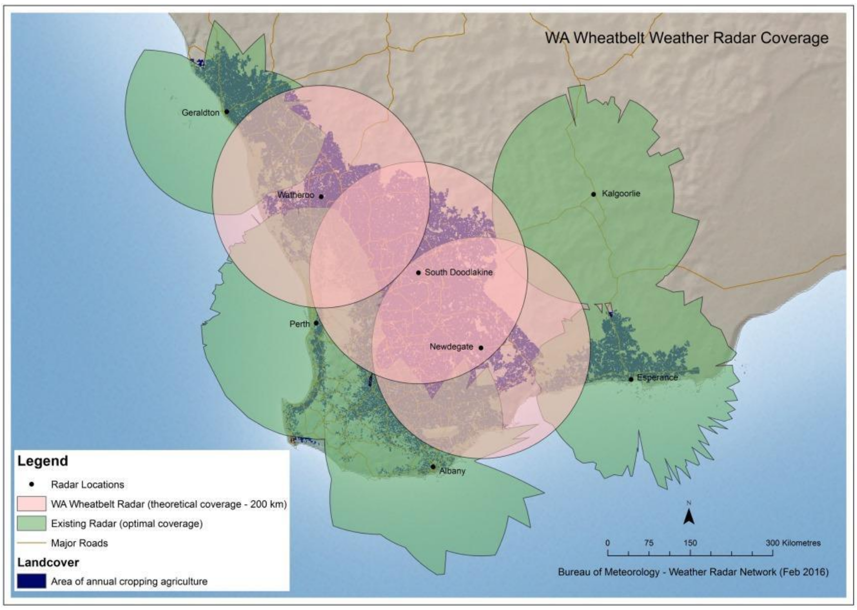

Fig 1. Location and coverage maps for the new radars, showing how they fill gaps in coverage over the WA grainbelt.

DAFWA is committed to acknowledging the traditional custodians of the land and with guidance from the South West Aboriginal Land and Sea Council, the radars have been given names to reflect Noongar traditions and their function.

Newdegate - Malkar Waadiny (looking for thunder cloud)

South Doodlakine - Maar Waadiny (looking for cloud)

Watheroo - Maar Warbiny Waadiny (looking for billowing cloud)

Interpretation of radar images

Estimated rainfall intensity and wind information will be shown as maps centred on the radar location. Interpretation of rainfall images is relatively easy, as they are related to the strength of the radar returns. Doppler winds are more difficult to interpret as the display only shows a component of the actual wind - the part that is blowing towards or away from the radar.

Another important aspect is measurement height. Weather radars are similar to a lighthouse - they generate a narrow beam of energy and rotate this beam through a full circle about every 20 seconds. The beam is generally angled upwards by a small amount to avoid interference from nearby objects or topography.

This means the beam gets higher above the ground as it moves away from the radar. The effect is exacerbated by curvature of the Earth, which makes the ground curve away from the radar beam with increasing distance from the radar. An additional complication is that the radar beam can be refracted (bent) by varying temperature and humidity conditions.

The result is the radar measurement height will rise from a few hundred metres within 20km of the radar, to over 3.5km at 150km range. Thus the map display of rain or winds shown on the web can be thought of as coming from an inverted cone within the atmosphere, centred on the radar site.

Rainfall echoes from the edge of the map display are from the middle levels in the atmosphere, and may rain not reach the ground, especially if the echoes are weak. Similarly, winds will reflect conditions higher in the atmosphere further away from the radar.

Other objects such as insects, dust or smoke particles can also show on the radar display, and can be concentrated by sharp wind shifts in sea breezes or troughs.

Results

There will be three categories of products coming from the radar project:

- Map displays of rain echoes, estimated rainfall and winds on the BoM website.
- Information products coming from integration of the radar data with other weather data, or as input to decision-support systems, such as accumulated rainfall levels at a paddock level.
- Improved weather forecasting for the grainbelt, especially for severe events such as thunderstorms and fire weather warnings.

Examples

The radars will show the familiar view of strength of returned signal, such as in Figure 2.

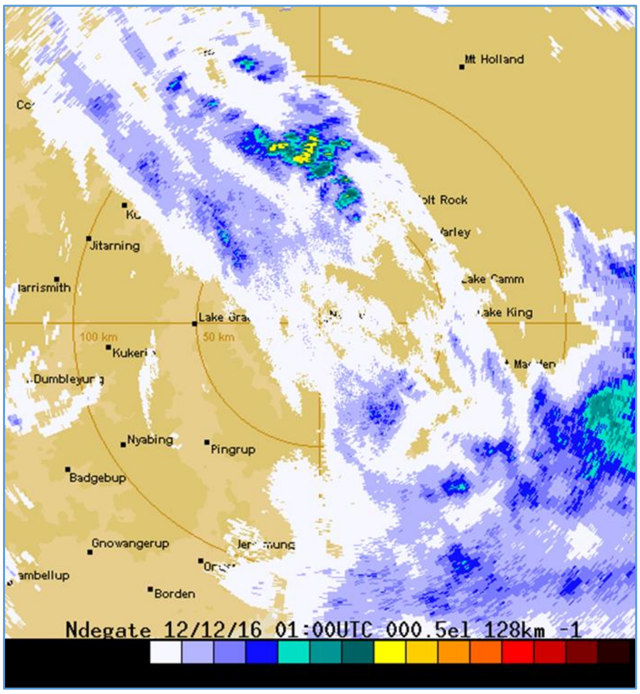

Fig 2. Display from Newdegate radar showing estimated rainfall intensity.

Using surrounding rainfall observations, this has been converted to estimated daily rainfall in Figure 3.

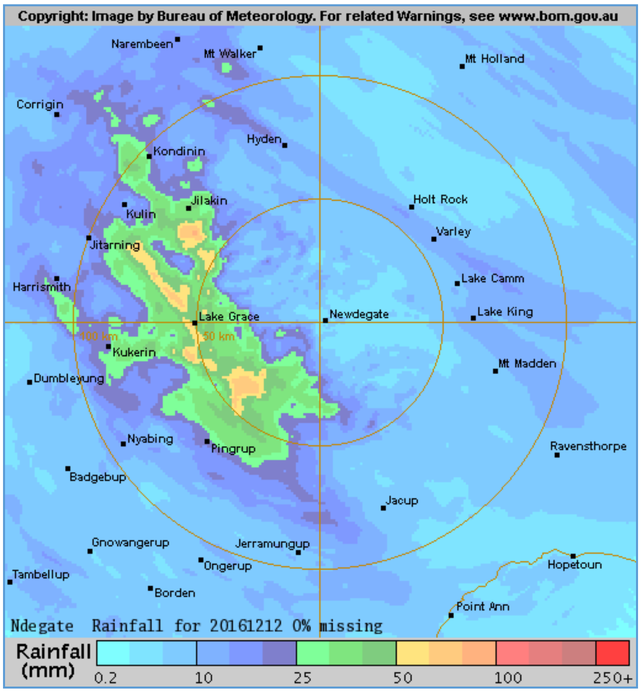

Fig 3. Estimated daily total rainfall at Newdegate radar.

Displays of wind are more complicated to interpret but offer insights into the structure and severity of associated with weather systems. Figure 4 shows winds surrounding thunderstorms east of Newdegate. At high levels there are northerly winds that are steering the storms in a southerly direction (red arrow). Closer to Newdegate, lower level winds are indicating a convergence of wind flow (black arrows).

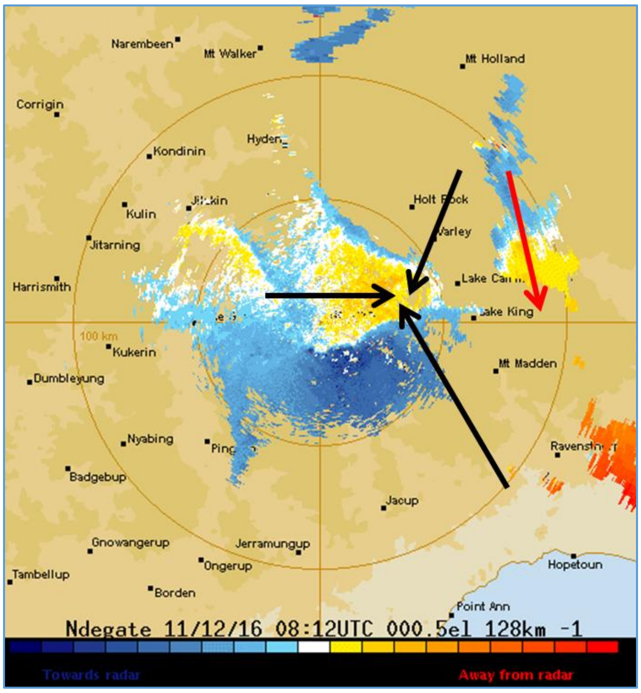

Fig 4. Display of wind components and resulting wind vectors from the Newdegate Doppler radar.

Conclusion

Installation of three Doppler radar stations in the WA grainbelt meets a long-standing need for radar coverage in the region. This has been achieved by a partnership between DAFWA and BoM, supported by the Royalties for Regions program.

These advanced systems will provide a range of real-time rainfall and wind information via the Bureau of Meteorology's website and be the catalyst for a range of agricultural applications developed by DAFWA and agribusiness providers.

Improvements in weather forecasting enabled by the radars will be particularly significant during severe weather events.

Conservative estimates of economic benefits from the radars and associated developments in decision-support exceed $100 million. There are likely to be further benefits accruing to regional communities through improved prediction of and response to severe weather events.

Key words

Doppler radar, grainbelt, weather forecasting.

Acknowledgments

State Government Royalties for Regions program provided funding for the three radar stations, and DAFWA funded additional weather stations to support rainfall calibration. This paper has been reviewed by John Connell, DAFWA.