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Improved Earthquake Monitoring around Adelaide

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ABSTRACT

Earthquake monitoring around Adelaide has improved significantly in the last seven years, with the addition of new stations by the Geological Survey of South Australia, Geoscience Australia, private seismologists and the Australian Seismometers in Schools Program. The Geological Survey of South Australia uses data from all these sources. This has significantly decreased errors in earthquake locations. In the past, depth estimates have often been poor, but now it is possible to estimate depth distributions. Detectability near Adelaide has improved from a nominal magnitude 1.6 to about 0.7 resulting in many more earthquakes being located. Focal mechanisms are now occasionally possible to be determined for earthquakes near Adelaide. When the current densification of stations spreads over a wider area, research may include velocity modelling, tomography and b-value variation.

Keywords: earthquake, monitoring.

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INTRODUCTION

More seismographs results in more earthquakes detected. Adelaide has had a major improvement in the last decade. This consisted of the first seismographs of the Geological Survey of South Australia that continuously recorded and telemetered data, and also a dedicated server performing collection, automatic epicentre location, and various display options. This has been followed by the installation of other stations by other groups. We review the improvements that have occurred, and what it will mean in future.

NETWORK EXPANSION

The Geological Survey of South Australia began a major network expansion around Adelaide in 2005, with extra funding through the Natural Disaster Mitigation Program. Most of these stations were low noise sites, well away from population centres. A few were in metropolitan areas to measure amplification. These stations were nearly all on-line to a central server. The most commonly used display is that showing the last hour of recording on all stations.

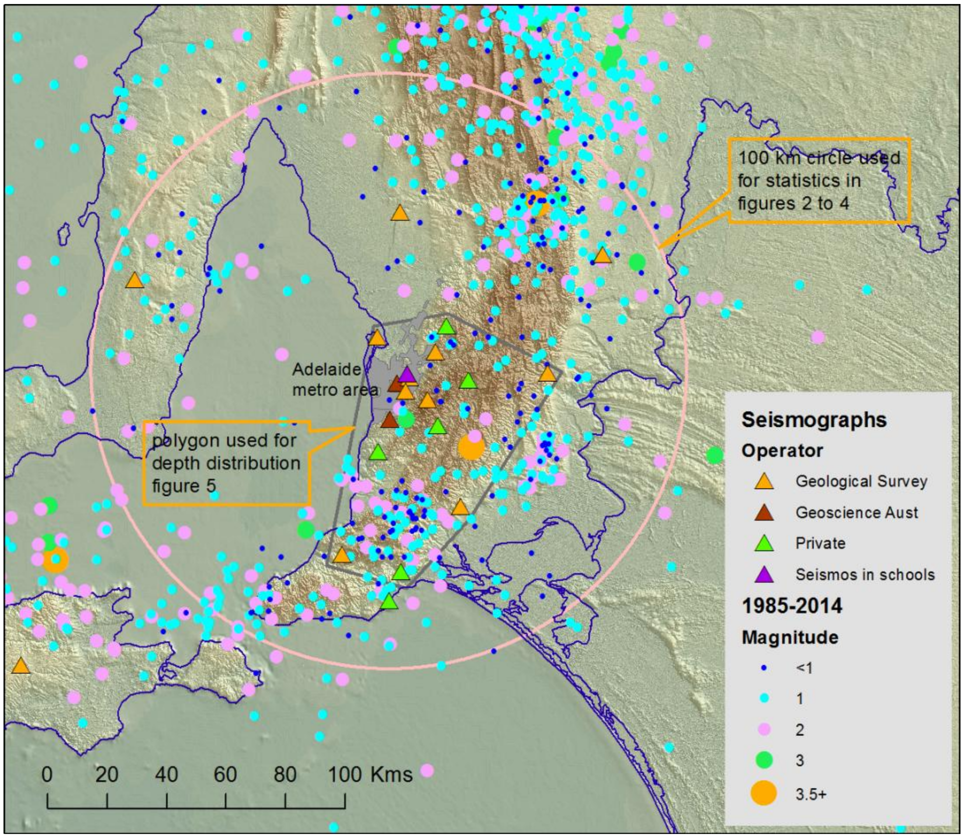

Figure 1: Seismicity and seismographs in the Adelaide region.

In following years, a few private stations were set up by enthusiasts. These sites are on-line and we are able to view, but not download the data at present. These sites are mostly very noisy, and not useful for earthquake detection.

Geoscience Australia now has two stations close to Adelaide, and one school has an instrument through the 'Australian Seismometers in Schools' program. These also are noisy sites.

Figure 1 shows seismicity and seismographs in the region around Adelaide, and Figure 2 shows the increase in seismograph numbers over recent decades.

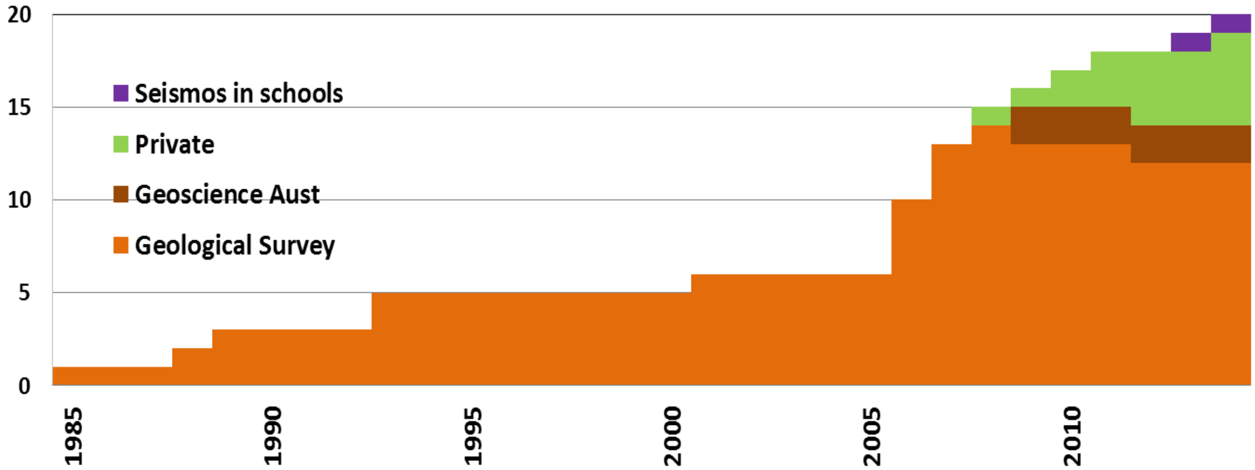

Figure 2: Number of seismographs within 100 km of Adelaide.

DETECTABILITY

The Geological Survey of South Australia network has enabled the detection of many more small earthquakes. The remaining stations are not useful for detecting events, however, once an earthquake has been detected by a sensitive station, it can often be found on the noisy stations, even without filtering, with useful arrival times to improve the location.

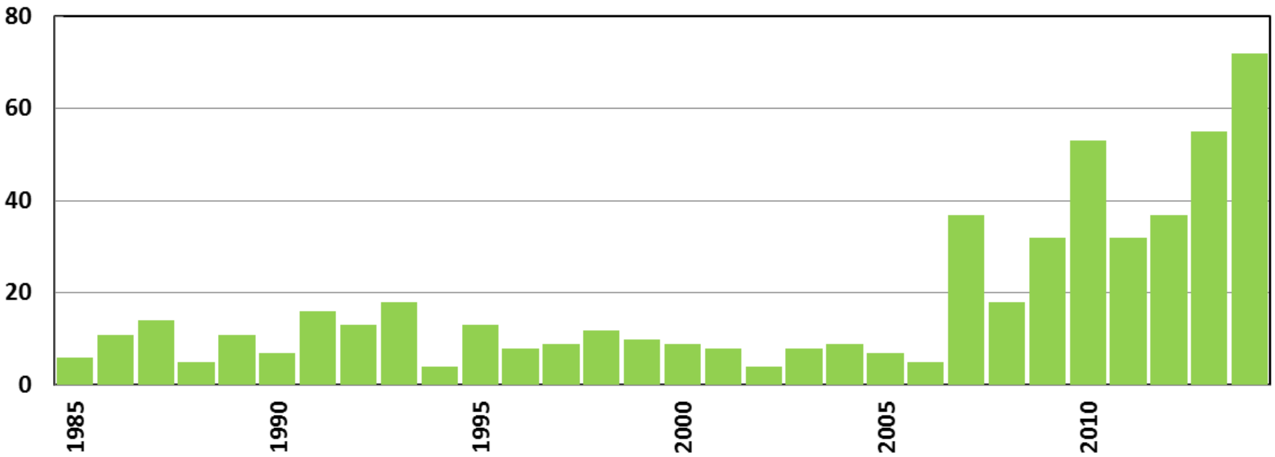

Figure 3: Number of events located annually within 100 km of Adelaide.

The increase in the number of events detected annually within 100 km of Adelaide is shown in Figure 3. This is mostly the result of the quiet Geological Survey of South Australia network and the hourly display. The noisier sites are not used to detect earthquakes but often add valuable information.

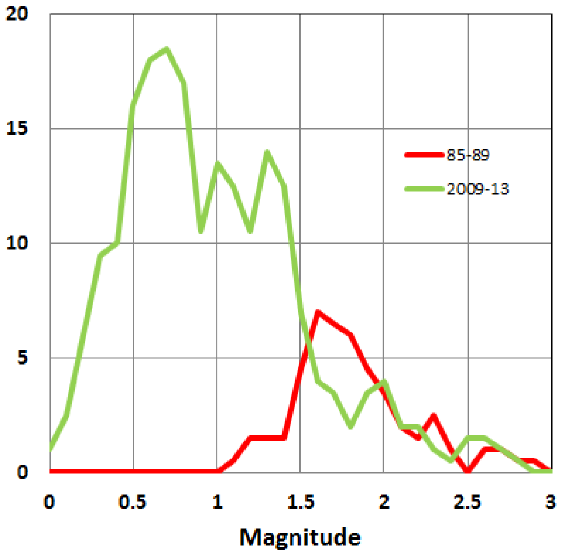

Figure 4: Detection capability of the network. In 1985-89 most events above magnitude 1.6 were recorded. In 2009-13 this improved to most events over magnitude 0.7

ACCURACY

The normal method of reviewing accuracy is by comparing error bars in the three directions; east, north and vertical. Events were selected from the Fleurieu Peninsula area (the polygonal area in Figure 1) with six being from the period 1985 to 1989 (see Figure 5 , blue set) and six from 2014 (red set). Horizontal errors in the first set, according to the Eqlocl program (2σ), scattered from 4.7 to 19 km, while in the second set these were from 2.2 to 5.5 km. In the 1985 to 1989 period the closest seismograph was usually ADE (Mount Bonython, near Adelaide), but the remaining seismographs recording the event were usually 200 km or further away. This suggests that some of the low error values are rather optimistic.

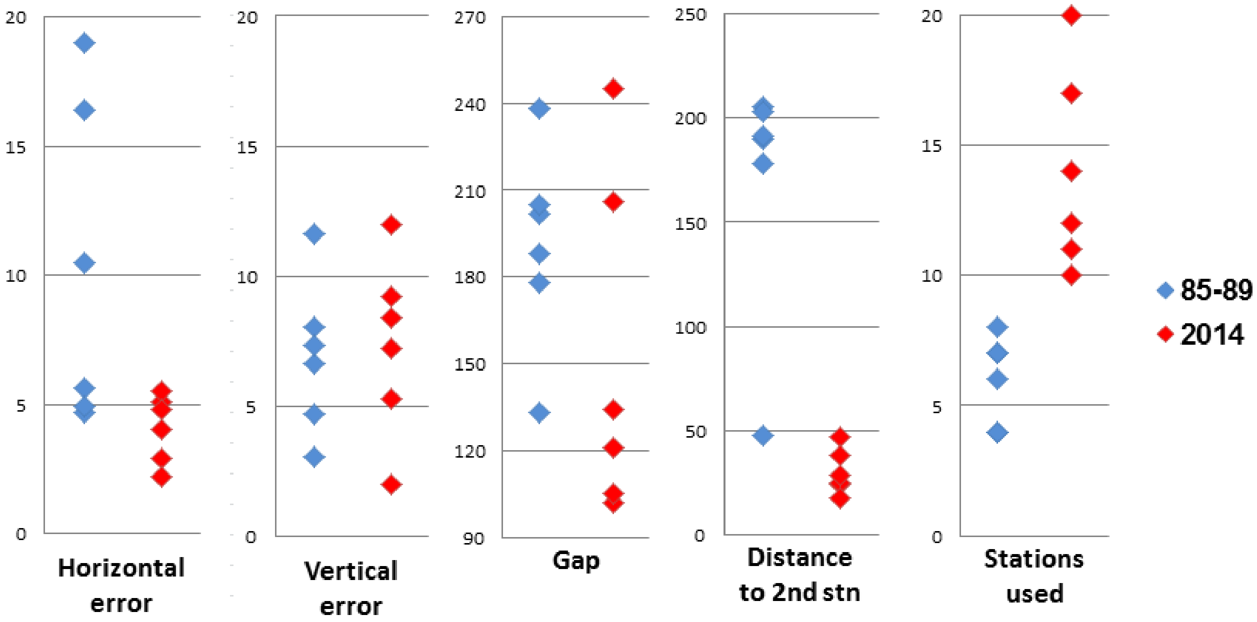

Figure 5: Comparisons in 5 parameters relating to accuracy.

In the vertical direction, errors in the 1985 to 1989 set varied from 4.7 to 11.6 km. In 2014 these were 2.0 to 12.0 km. This larger value was from a very small event, and larger events gave lower errors, typically 2.0 to 8.4 km. This is still not a significant improvement, and is clearly not a true indication of reality. In earlier years, standard practice was to read phases other than just P and S. Refracted and reflected arrivals were often included, resulting in better depth estimates according to the Eqlocl program. Addition of reflected phases in the second set would improve the quoted accuracy, but is unlikely to affect most depths.

Another measure of accuracy is the largest angle gap in the epicentre location. This was typically 200 degrees or more in earlier times. The best stations were to the north and south, resulting in greater east-west uncertainty, unless the event was recorded to the west by the noisier Cleve station. While some events now still have maximum gaps of over 200 degrees, it is more commonly 100 to 130 degrees. This must clearly produce greater confidence in epicentre locations.

The number of stations recording an event has increase from the range 4 to 8, to the range 8 to 20, even though the magnitudes are lower. This substantially increases confidence in the solutions.

DEPTH DISTRIBUTION

For the polygon region shown in Figure 1, where the seismograph density is greatest and the vertical errors likely to be least, the depth distribution in Figure 6 was obtained. It shows that events occur down to a depth of about 30 km. Depths seem to be reasonably spread from surface to that depth, although there are less at shallower depths.

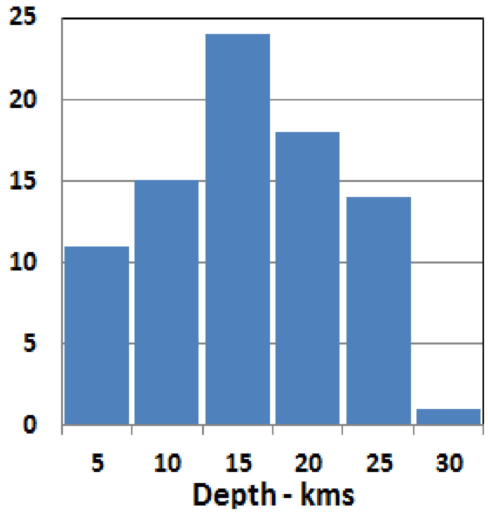

Figure 6: Depth distribution of more accurate hypocentres.

SUMMARY

It is clear that some of the parameters intended to show accuracy are not always reliable, but a mix of parameters gives greater confidence in the accuracy of solutions.

With the increasing numbers of earthquakes being detected and the improved confidence in the hypocentral solutions, it is now sometimes possible to produce a focal mechanism with even a moderately small magnitude event. When the event is more than 10 km deep, the distribution of departure angles and clarity of the first arrivals mean that focal mechanisms of reasonable quality are possible.

It is hoped that with the higher density of stations expanding across the area, more velocity modelling and tomography will be possible.