Australian Government
Geoscience Australia

International Monitoring System's Detection and Screening Capability in Australia

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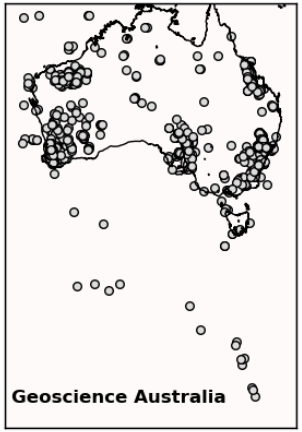
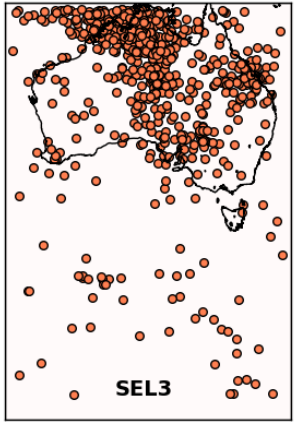
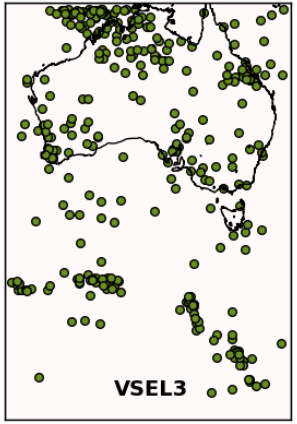
Background and motivation

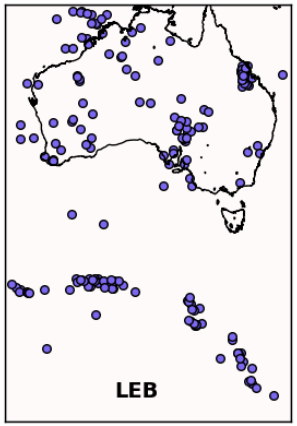
- To produce LEB and REB nearly every event in SEL3 must be corrected by hand
- For over a year the CTBTO Analysts have been testing the “VISA button” ➔ after analysing all the events from SEL3 formed by the Global Association (GA) algorithm, they would analyse the events from VSEL3 formed by the Bayesian NET-VISA algorithm
- NET-VISA uses probabilistic inference to work out the seismic bulletin which best explains a set of arrivals at IMS primary and auxiliary stations
- One of the goals of NET-VISA to produce fewer false events without missing any events and find more events that will pass analyst scrutiny ➔ ultimately this should lead to reducing the analysts’ work load
- NET-VISA’s Generative Model contains prior probability distribution functions (PDF) which give instructions for evaluating the probability of an event and set of arrivals
- The Event Location PDF is related to the tectonic geography of the Earth with added small uniform probability to allow for explosions happening anywhere in the globe
- The analyst curated Late Event Bulletin is used as ground truth for the Generative Model’s event location prior
- Questions: How well are GA and VISA performing in Australia? Particularly can VISA reduce the analysts’ workload in this region? Are all the events captured?

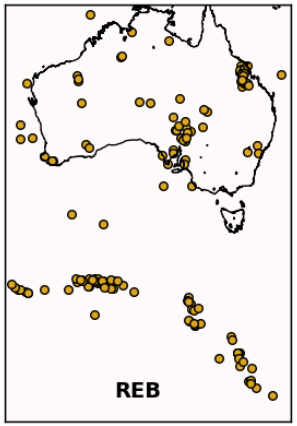
We examined the pictured bulletins **between 23rd of May and 31st of December 2018**, with a particular focus on comparison to LEB

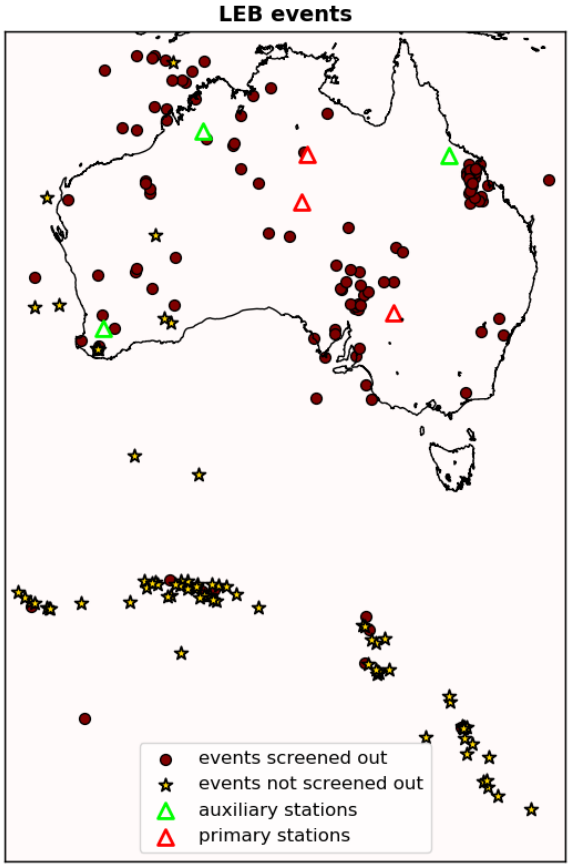












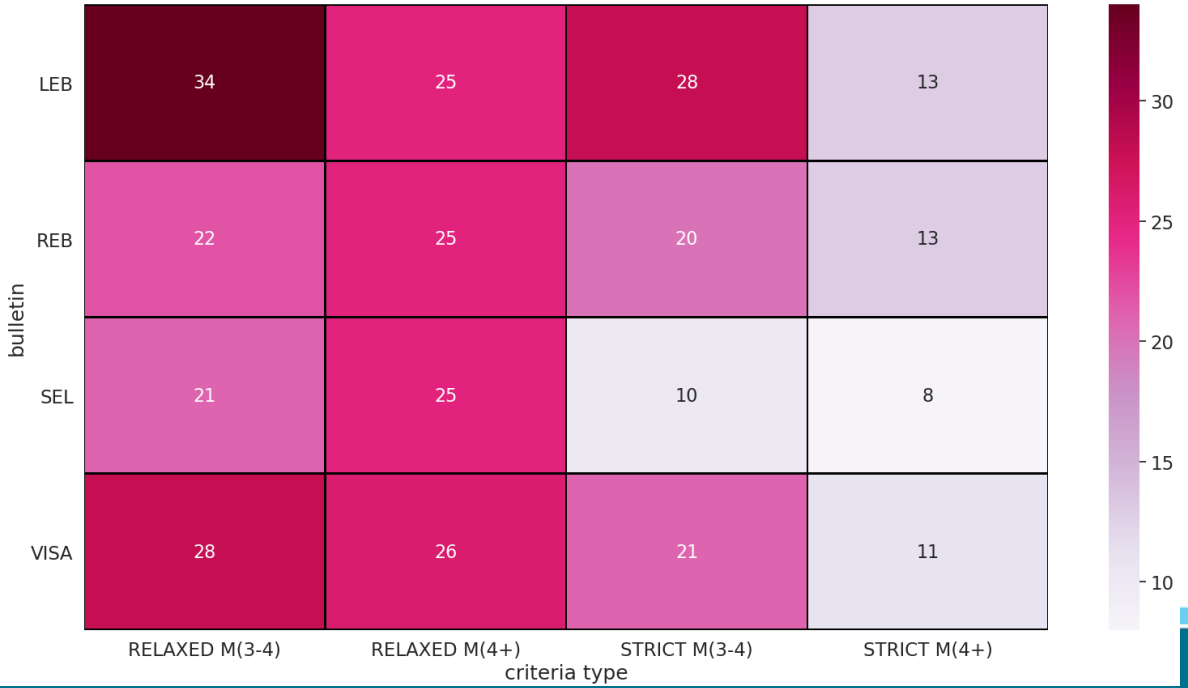
Comparing the bulletins with Geoscience Australia

The events in every bulletin were matched to the bulletin of Geoscience Australia's National Earthquake Alerts Centre using the following criteria:

(1) Two magnitude categories: (a)ML 3-4 and (b)ML 4 and above

(2) Relaxed location and time criteria: epicentres within **200km** of each other and origin times (OT) within **60s** of each other

(3) Strict location and time criteria: epicentres within **200km** of each other and OT within **10s** of each other



- 115 events in Australia in magnitude range M3-4

The differences in numbers for M3-4 range may be due to:
(1) Poor locations using only (primary) IMS stations
(2) Differences in magnitude calculation

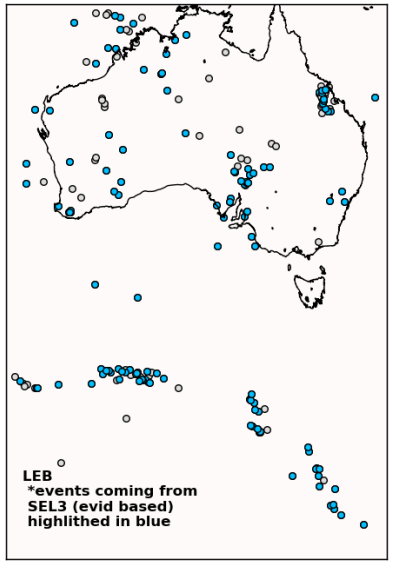
- ✓ 25 events in Australia in magnitude range M4+

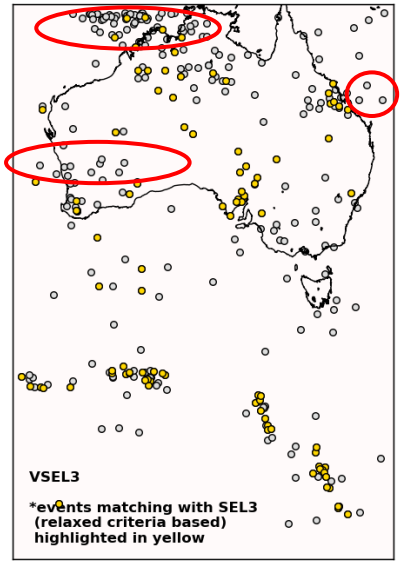
- Bulletins are complete for M4+
- VSEL3 matched two of its events with one and the same event on the Antarctic ridge

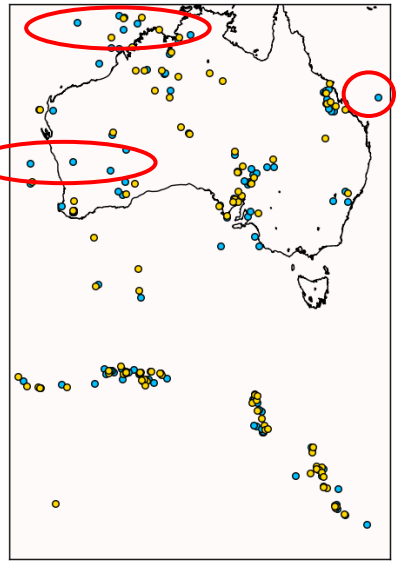
Comparing SEL and VISA

Using relaxed (lax) criteria we matched VSEL3 events with events in SEL3.

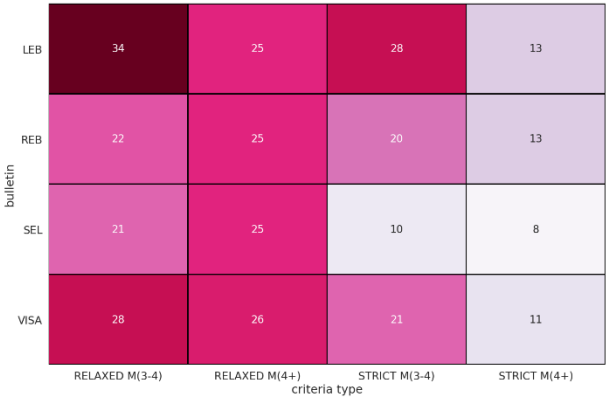
We compare the matched events with events in LEB that come from SEL





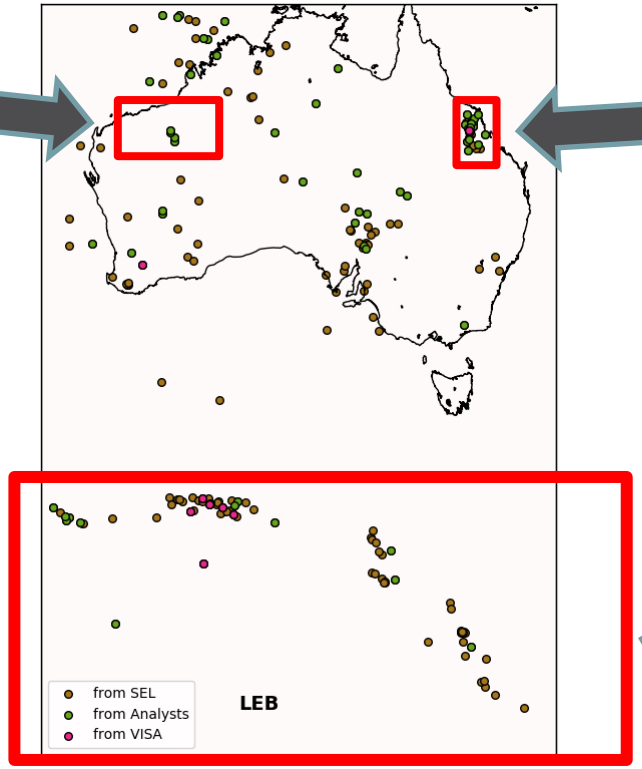


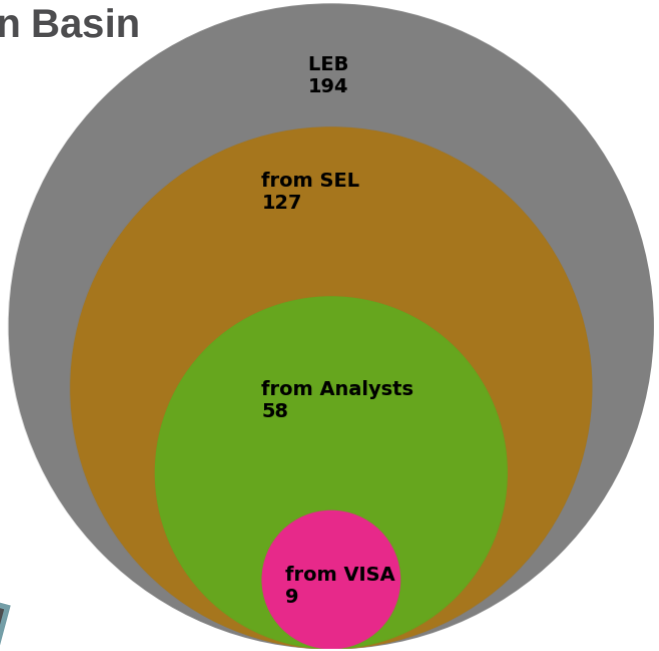
VSEL3 events cover well the LEB events that come from SEL



- Under the assumption that all the events in SEL3 and/or VSEL3 matching with Geoscience Australia go to LEB ➔ VISA is performing equally well or even marginally better (28 vs 21 events lax criteria, 21 vs 10 events strict criteria)
- For a potentially similar end result (21 or 28 events contributed to LEB) VISA (total of 326 events to review) creates less work for human analysts than GA(SEL) (total of 1309 events to review)

LEB sources

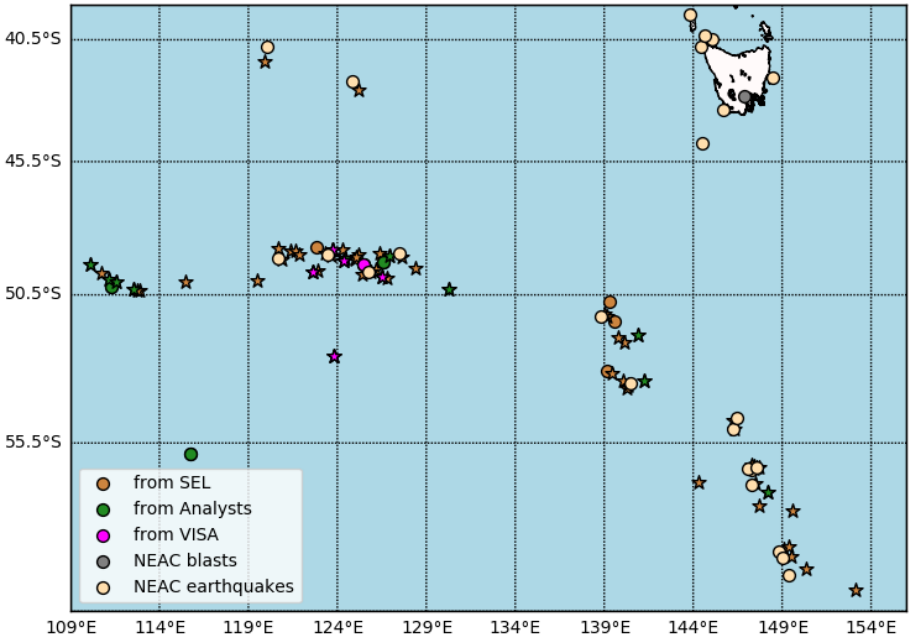


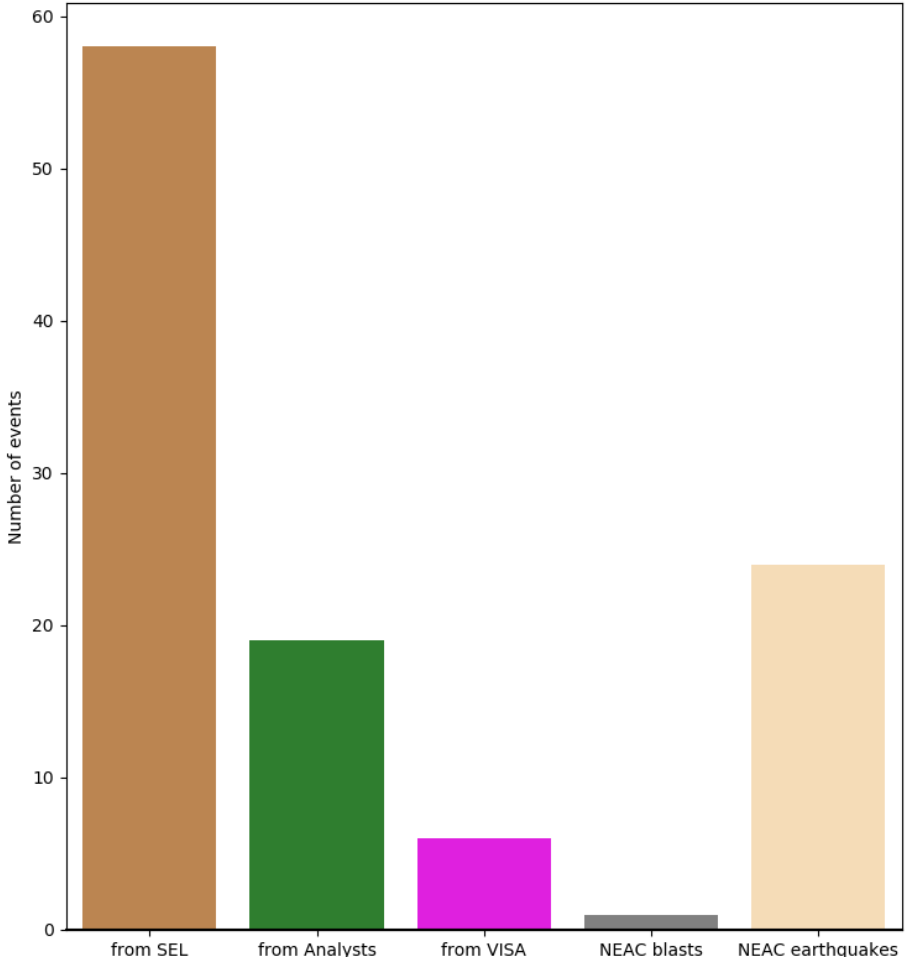


- Human analysts still manually create a significant number of events in LEB, more than VISA does
- Why is that?

Are these events in regions where GA(SEL) and VISA are not performing well?

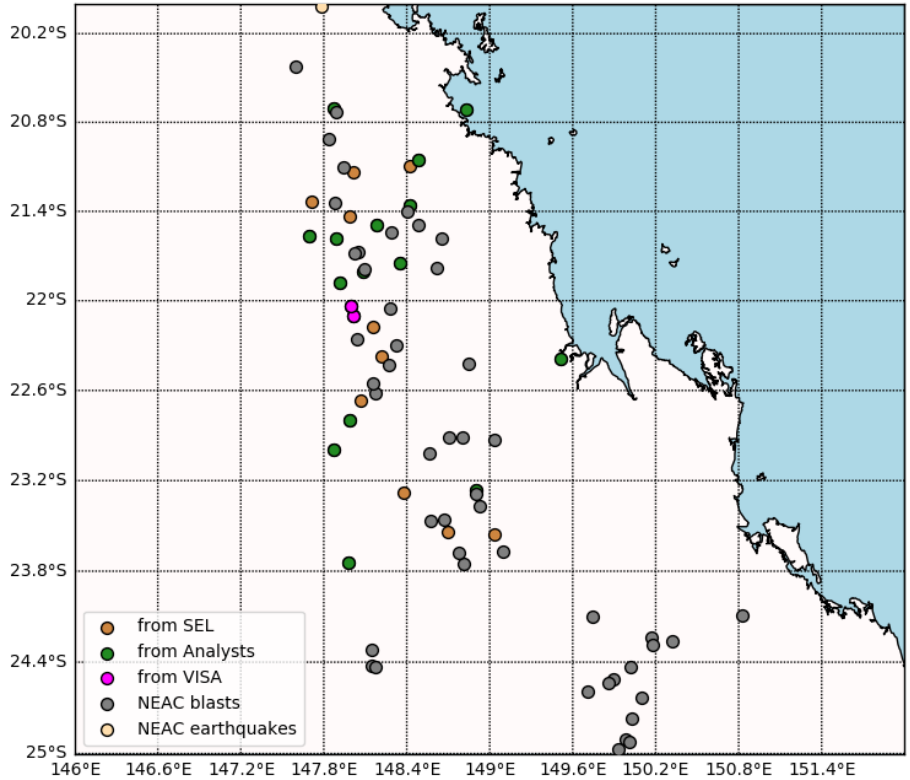
Events in the Southern Ocean. Comparing LEB with Australia's National Earthquake Alerts Centre (NEAC).

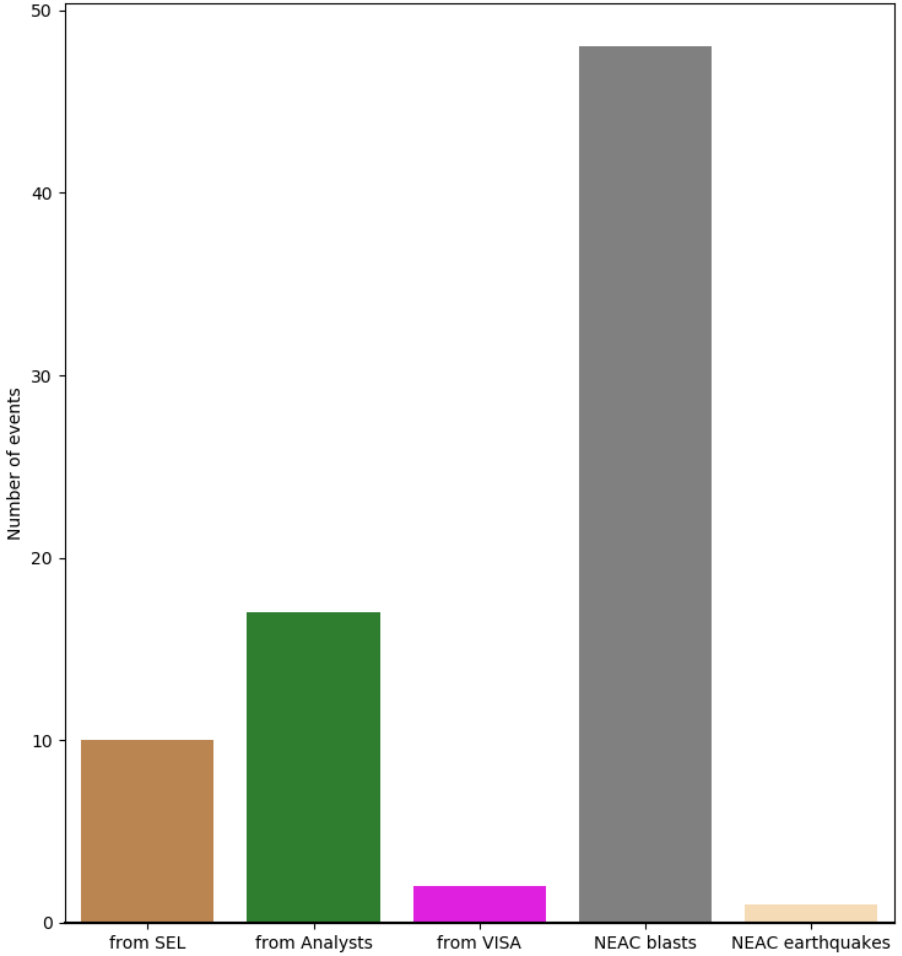




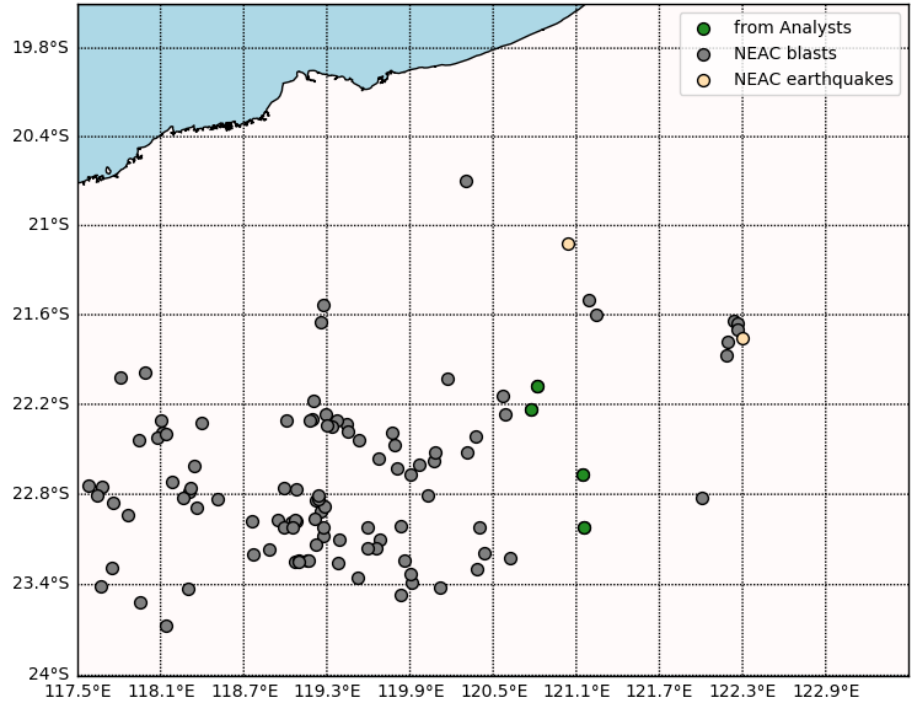
*events plotted as stars have screen scores less than zero (have not been screened out)

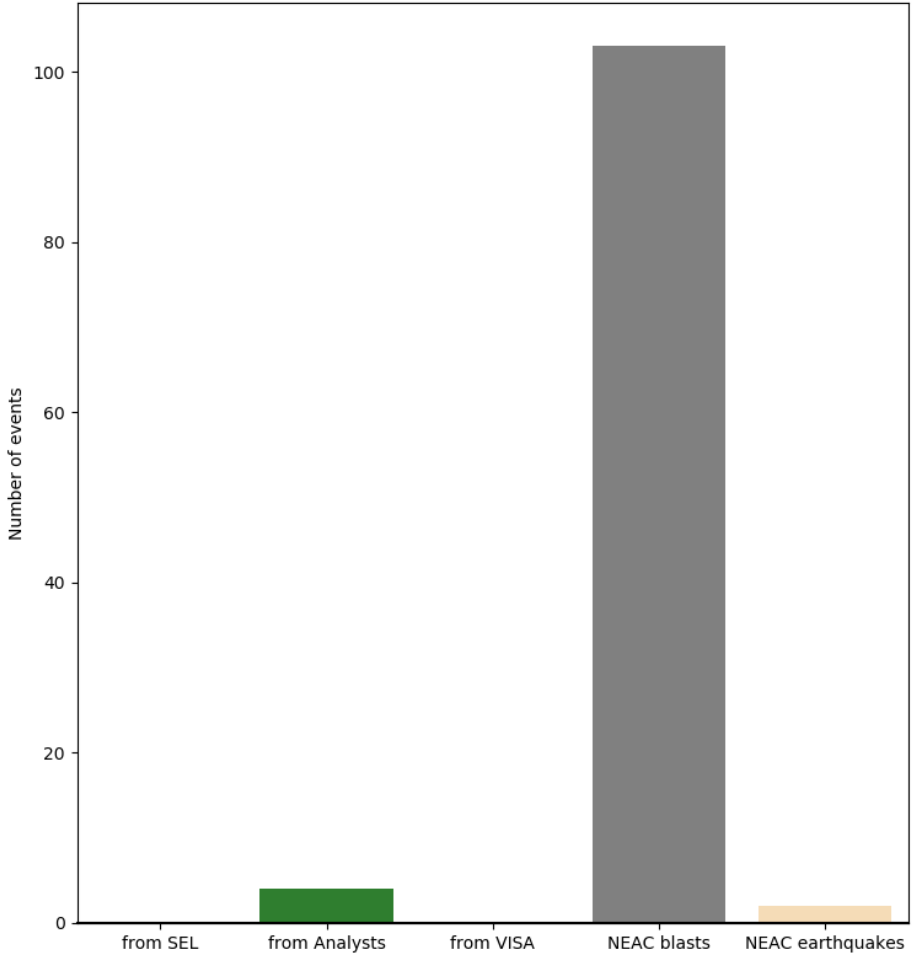
Events in the Bowen Basin, QLD. Comparing LEB with Australia's National Earthquake Alerts Centre (NEAC).





Events in the Pilbara Region. Comapring LEB with Australia's National Earthquake Alerts Centre (NEAC).





The SEL and VISA bulletins were compared to Australia's NEAC bulletin for the time period of 23.05.2018 to 31.12.2018

SEL3 has 1309 events recorded for this period and region, VISA has 326 events recorded

VISA performs equally well or marginally better than Global Association algorithm in this region ➔ numbers of matched events with NEAC are similar and/or equal for certain criteria

Human analysts are still significantly contributing to LEB through manual formation of events - - why?

In the Bowen Basin and Southern Ocean regions LEB has contributions from SEL and VISA, however human analysts still have a lot of work to do

In Pilbara SEL and VISA are not capturing events at all! - - why?

- VISA is trained on LEB: if there are no events in LEB to start with, VISA "learns" there are no events in the region. Small uniform location prior seems to not be effective in Pilbara
- Pilbara is approximately the same distance from ASAR and WRA arrays (both primary IMS arrays) as is Bowen Basin – are the frequency bandwidths of these arrays not well suited to high-frequency signals in Western Australia?

Suggestion: VISA should be trained on local NDC databases, not LEB ➔ reduce chances of missing an event, provide better ground truth model and consequently better prior probability distribution functions

Thank you

References:

Arora, Russell, Kuzma, 2017: NET-VISA Software Description Document, Document Version 1.3

Summary of NET-VISA Evaluation and Testing, ECS/WGB-50/PTS/14

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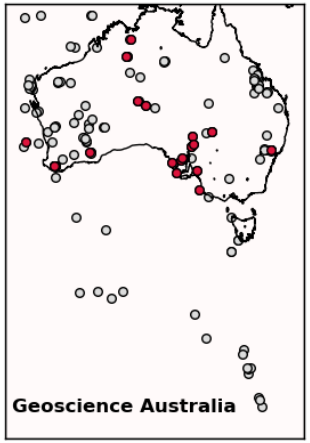
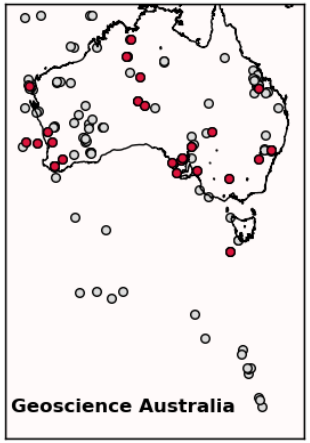
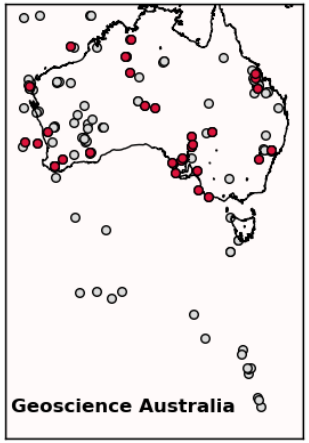
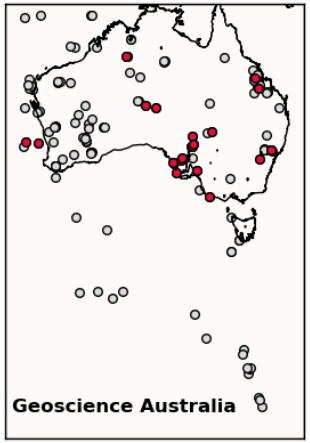
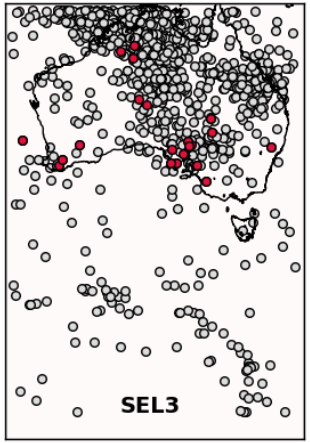
Relaxed criteria-based matched events for 3<M<4

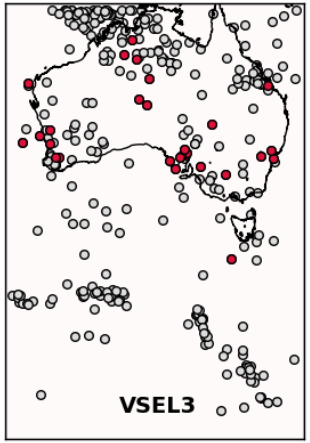


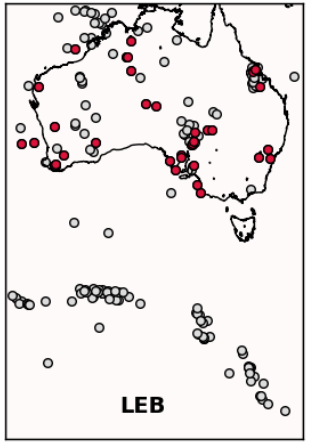


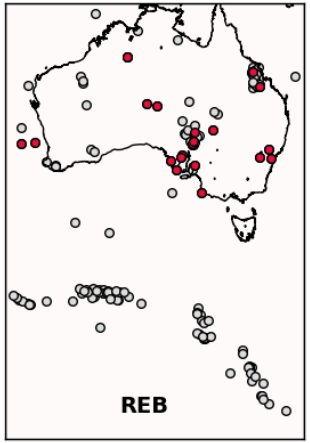




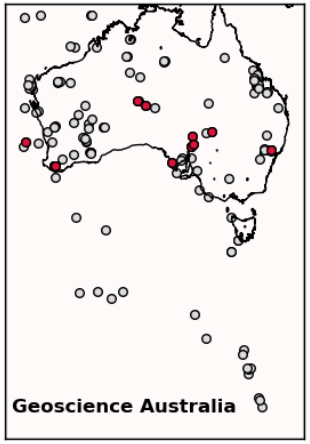


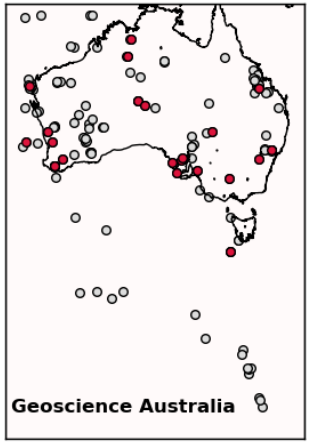


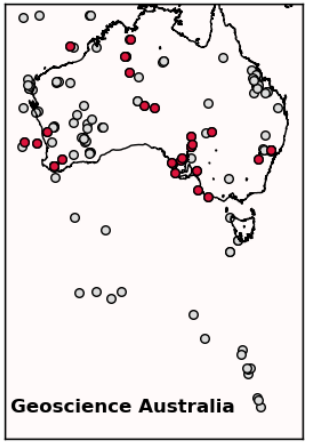


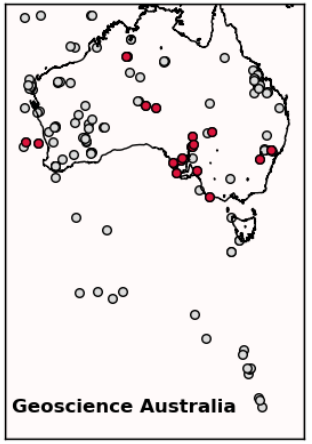


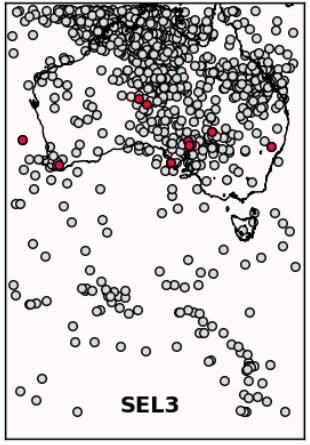
Strict criteria-based matched events for 3<M<4

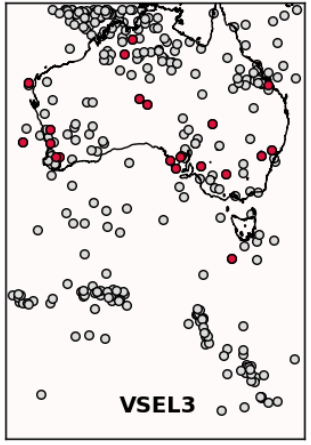


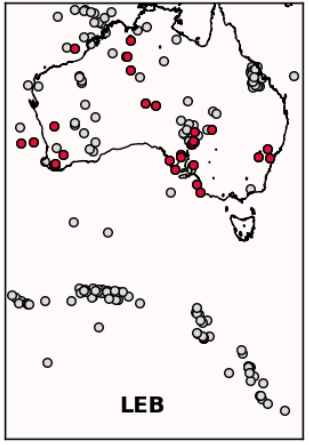


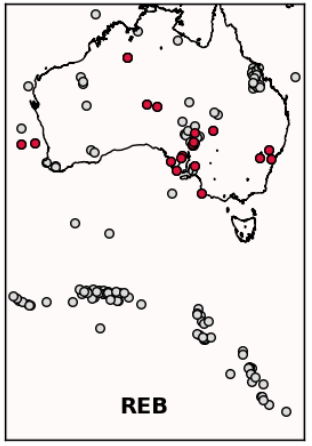




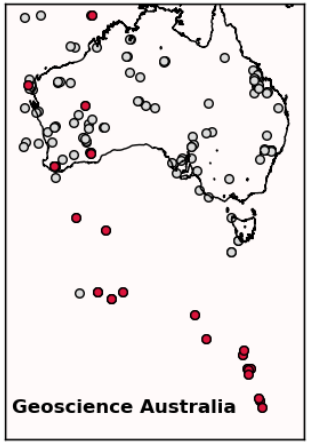


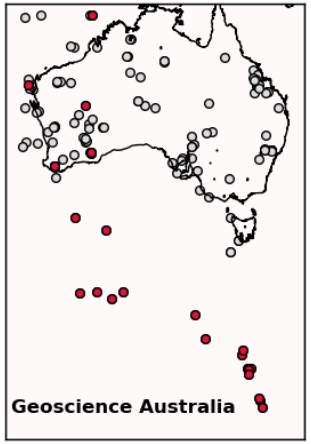


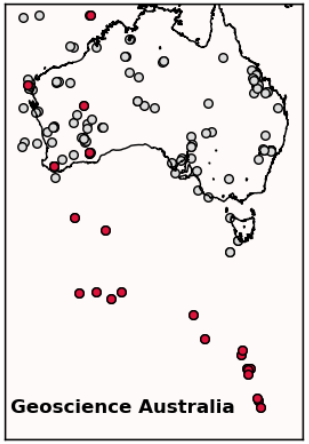


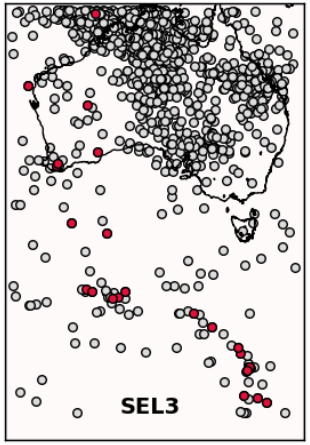


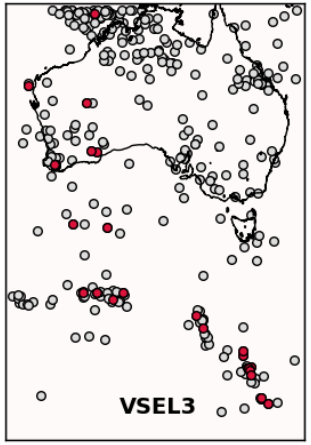
Relaxed criteria-based matched events for M>4

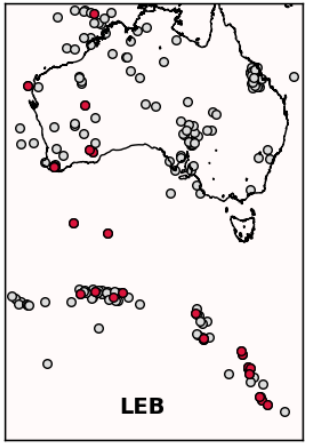


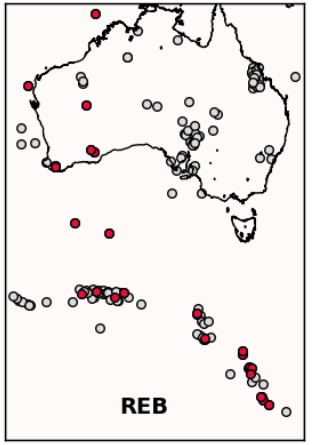




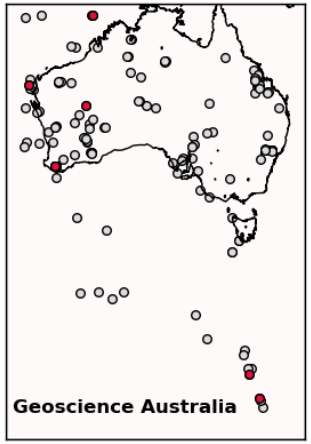


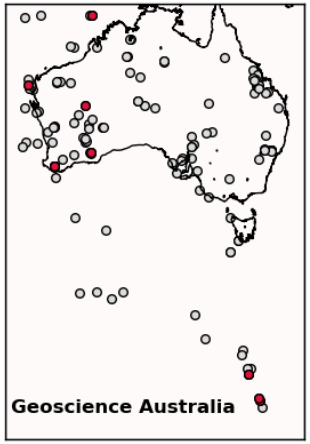


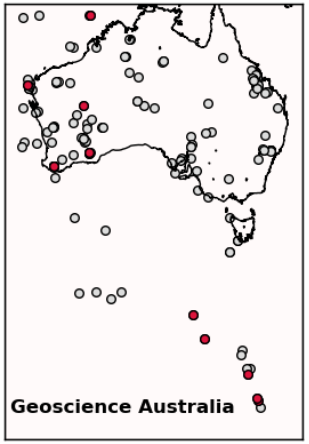


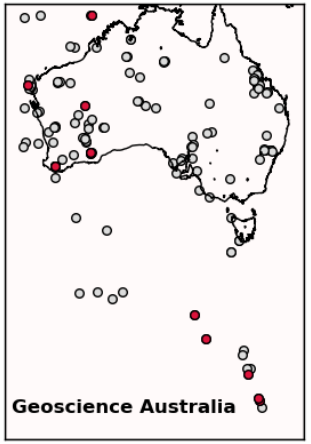


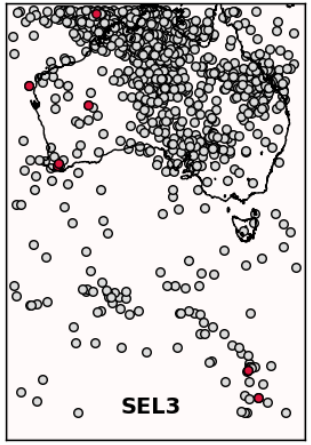
Strict criteria-based matched events for M>4

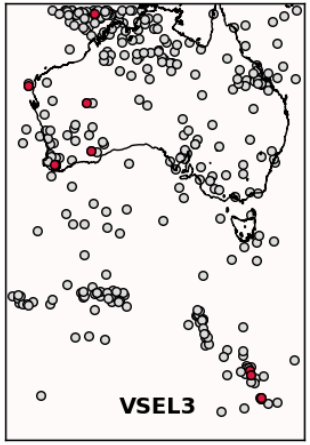


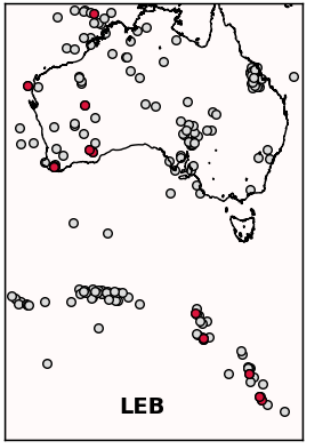


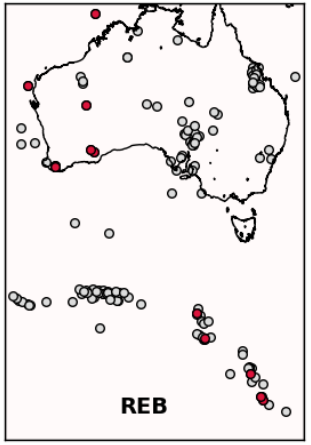


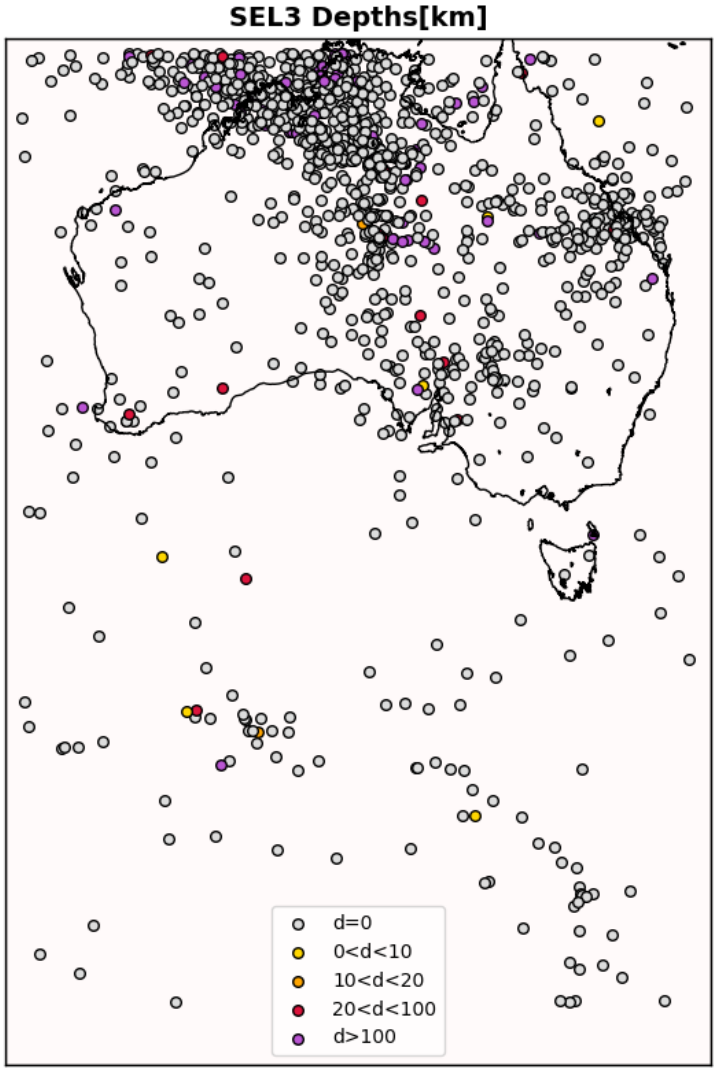


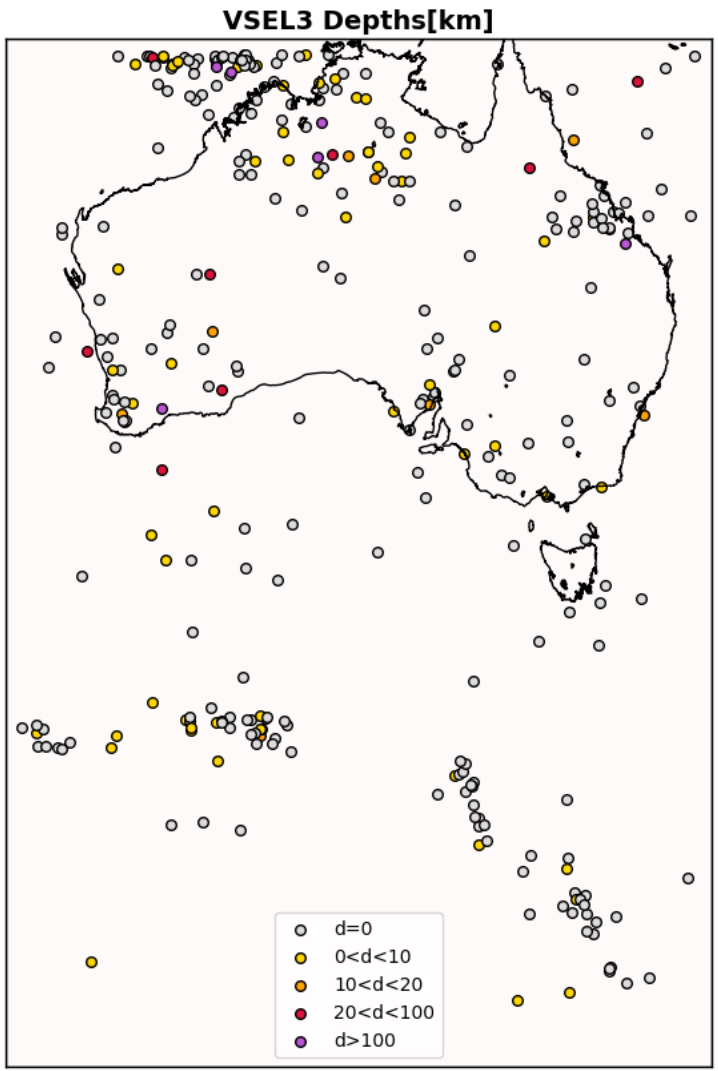


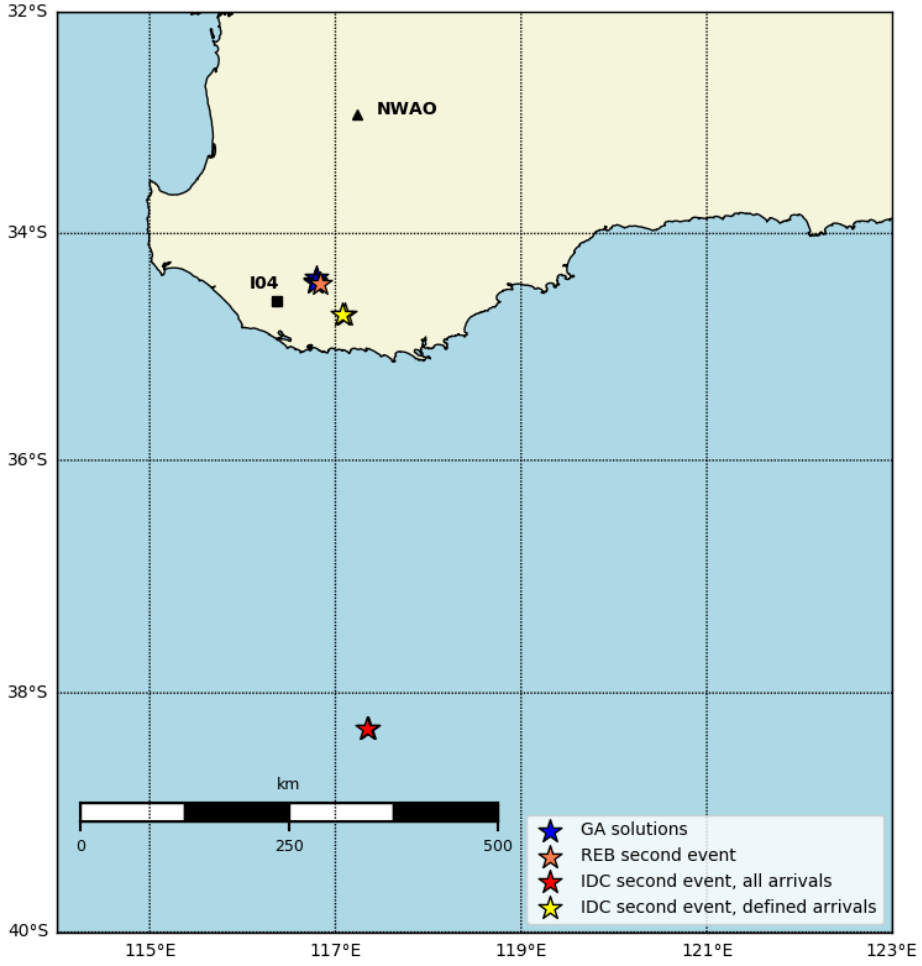


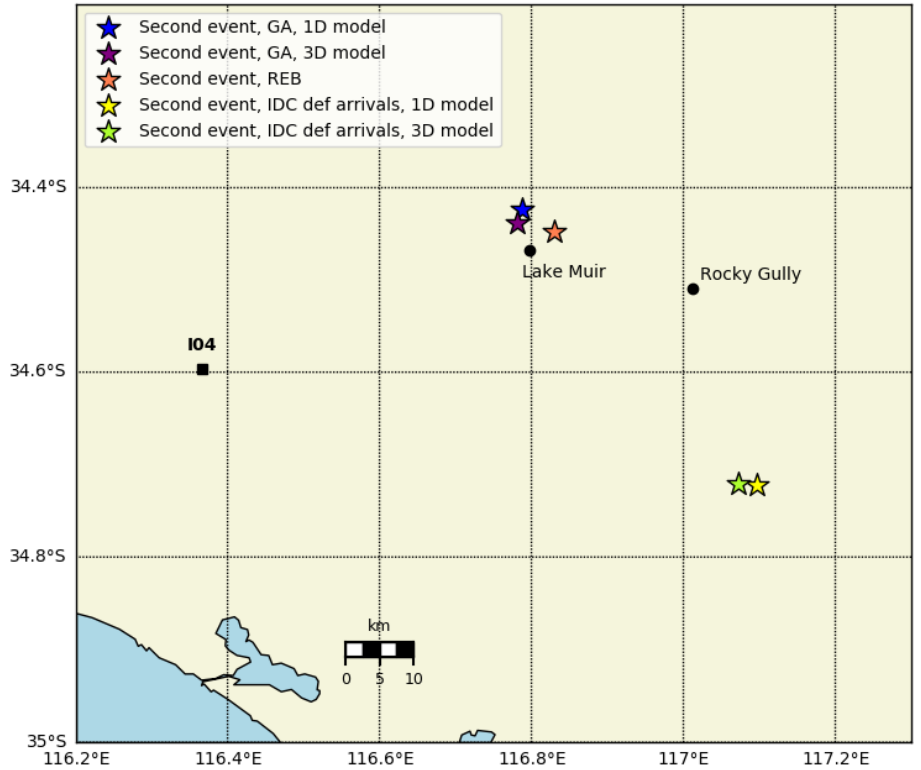





SEL3 Depths[km]
d=0
0<d<10
10<d<20
20<d<100
d>100


VSEL3 Depths[km]
d=0
0<d<10
10<d<20
20<d<100
d>100


32°S
34°S
36°S
38°S
40°S
115°E
117°E
119°E
121°E
123°E
NWAO
I04
km
0
250
500
GA solutions
REB second event
IDC second event, all arrivals
IDC second event, defined arrivals


Second event, GA, 1D model
Second event, GA, 3D model
Second event, REB
Second event, IDC def arrivals, 1D model
Second event, IDC def arrivals, 3D model
34.4°S
34.6°S
34.8°S
35°S
116.2°E
116.4°E
116.6°E
116.8°E
117°E
117.2°E
Lake Muir
Rocky Gully
I04
km
0
5
10