Teleseismic imaging in southeast Australia

using data from multiple high density seismic arrays

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Outline

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1. Passive arrays in southeast Australia
   - Array distribution
   - Data volume and reduction
2. Results from TIGGER and SEAL
   - Teleseismic tomography
   - The Tasmanian lithosphere
   - Structure beneath the Murray Basin
3. Combining multiple datasets
   - Common classes of seismic data
   - A robust tomographic inversion scheme
   - Preliminary results
4. Overseas analogues - the USArray

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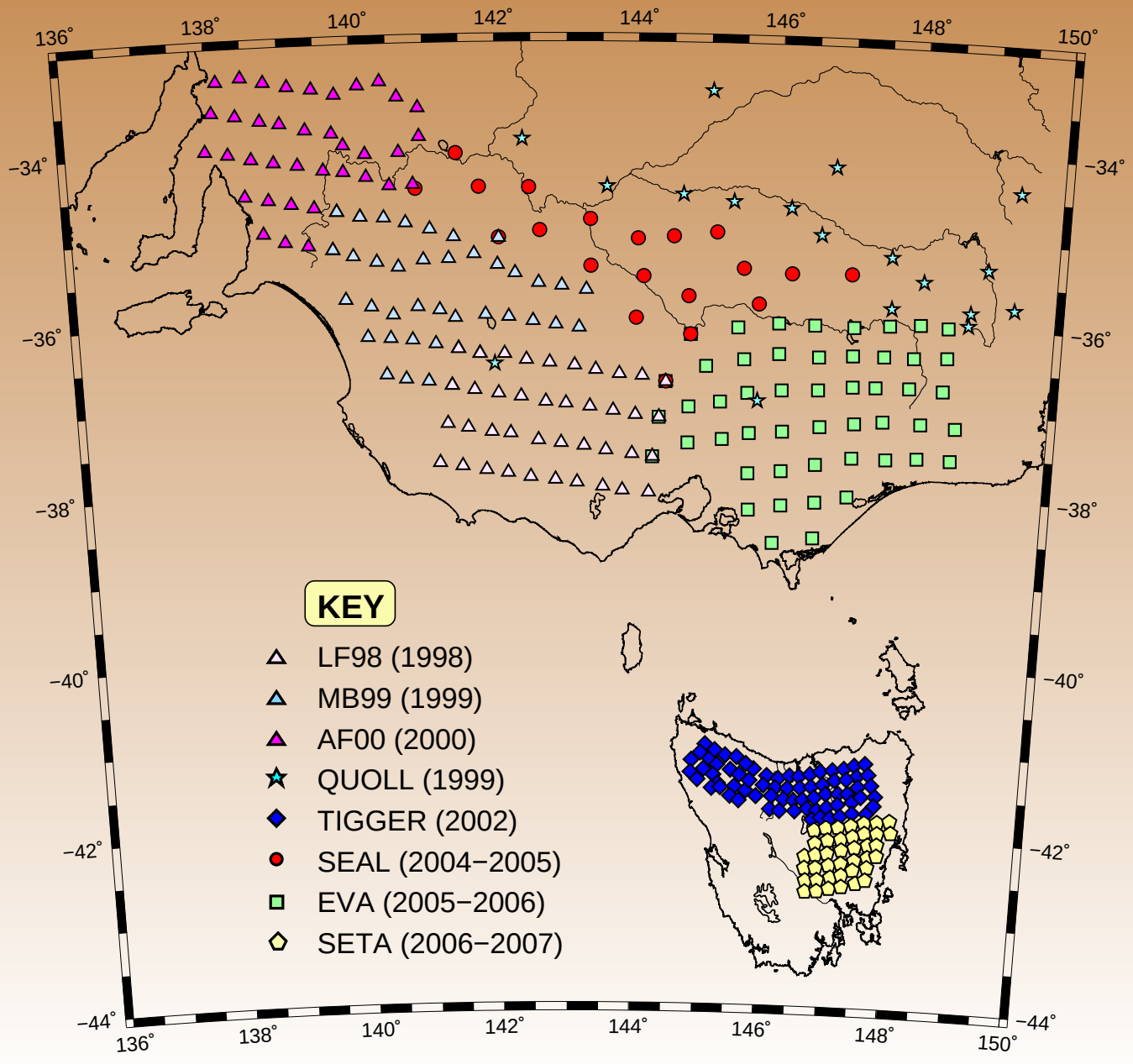
Passive arrays in southeast Australia

Array distribution



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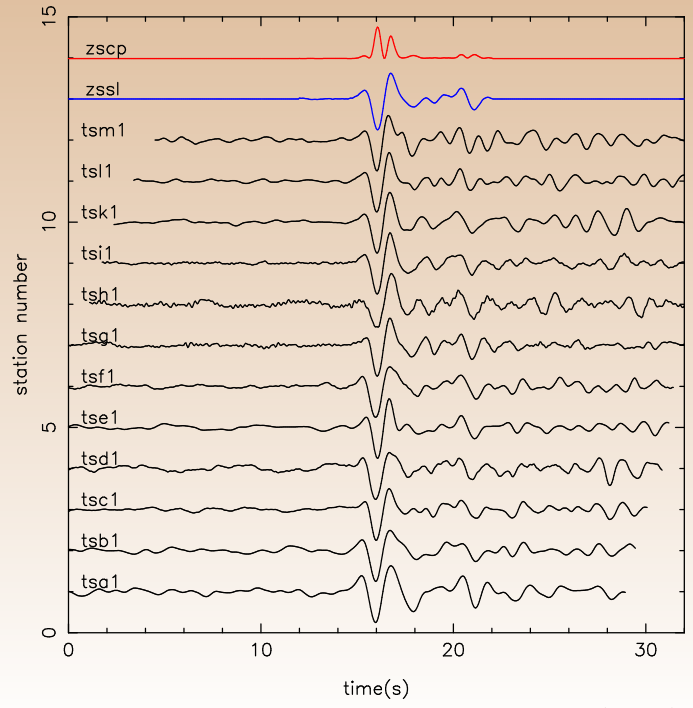
Passive arrays in southeast Australia

Data volume and reduction

Experiment	Duration (months)	Number of Stations	Sample rate (samples/s)	Number of Components	Data (Gb)
LF98	4	40	20	1	20
MB99	4	40	20	1	20
AF00	4	40	20	1	20
QUOLL	6	20	25	3	50
TIGGER	5	72	20	1	45
SEAL	5	20	20	1	12
EVA	8	50	25	1	62
SETA	8	40	25	3	150
TOTAL	**44**	**322**			**379**

Passive arrays in southeast Australia
Data volume and reduction

- The data reduction and extraction process involves:
  - Extract data windows (30-60 minutes) for large events
  - Identify global seismic phases e.g. P, PP, PcP etc.
  - Estimate arrival time of associated wavetrain
- This entire process can be done in a semi-automated fashion, resulting in 10s of Gb of data being reduced to 10s of Kb.



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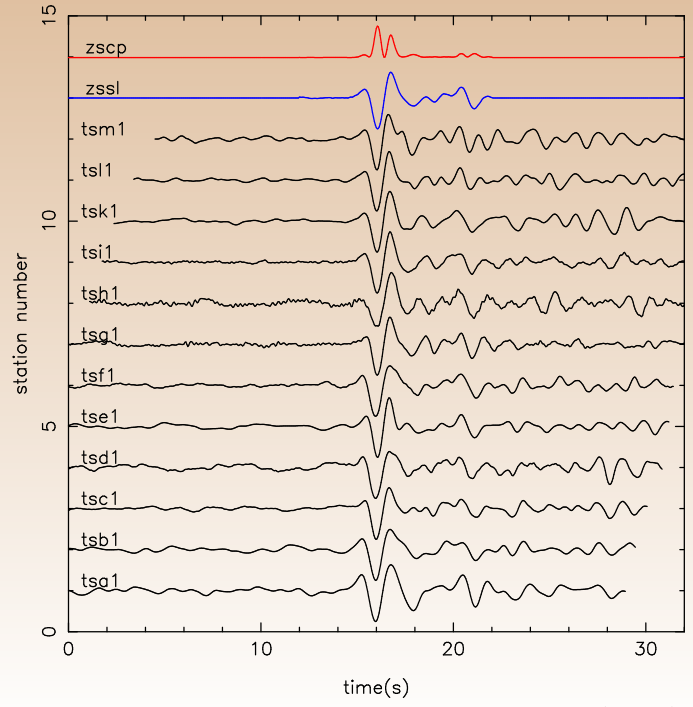

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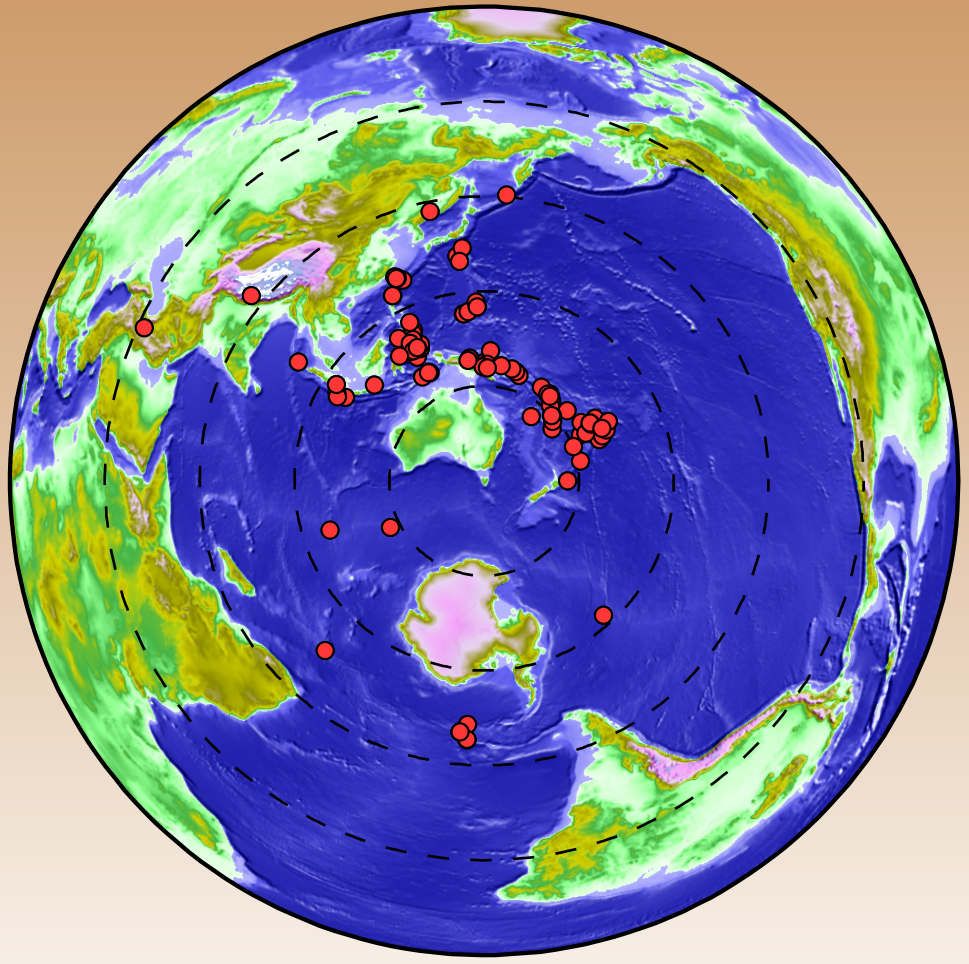
Results from TIGGER and SEAL

Teleseismic tomography



- 101 teleseismic events
- 110 phases
- P, PP, PcP, ScP, PKiKP
- 6,520 paths
- Good coverage from north and east
- Poor coverage from south and west

Results from TIGGER and SEAL

Teleseismic tomography

Iterative non−linear inversion scheme

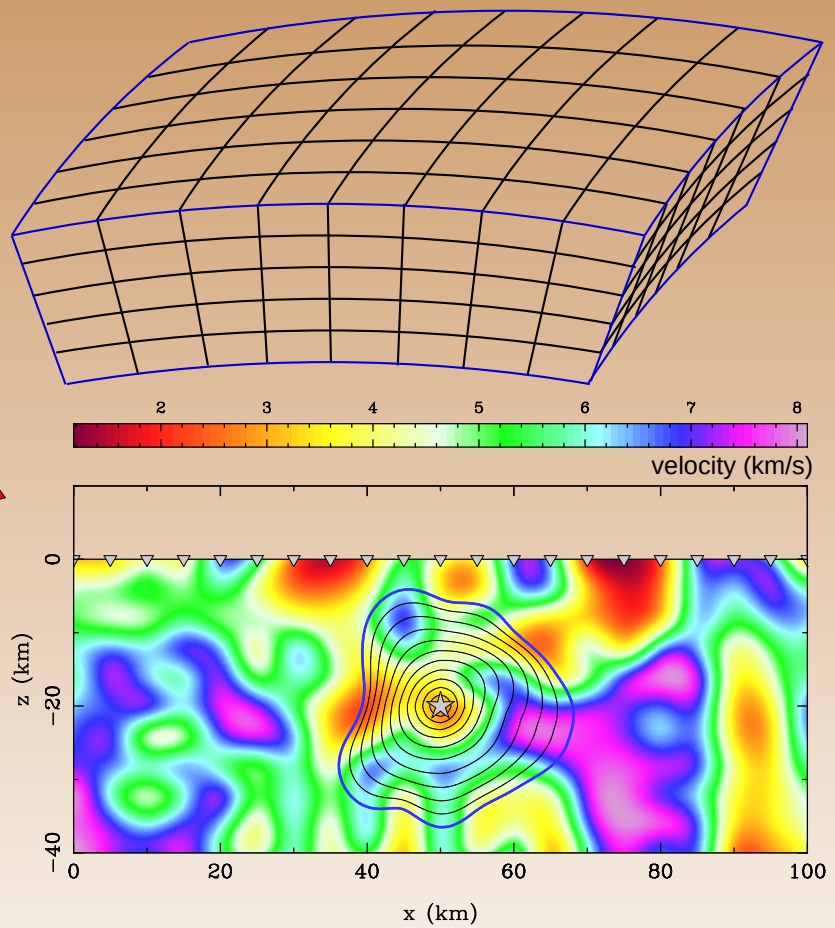
$$\mathbf{m}_{n+1} = \mathbf{m}_n + \delta\mathbf{m}_n$$

Model parameterization
Cubic B−splines

Traveltime prediction
Fast marching method

Inversion method
Subspace inversion

$$\delta\mathbf{m} = -\mathbf{A}\left[\mathbf{A}^T(\mathbf{G}^T\mathbf{C}_d^{-1}\mathbf{G} + \varepsilon\mathbf{C}_m^{-1} + \eta\mathbf{D}^T\mathbf{D})\mathbf{A}\right]^{-1}\mathbf{A}^T\gamma$$



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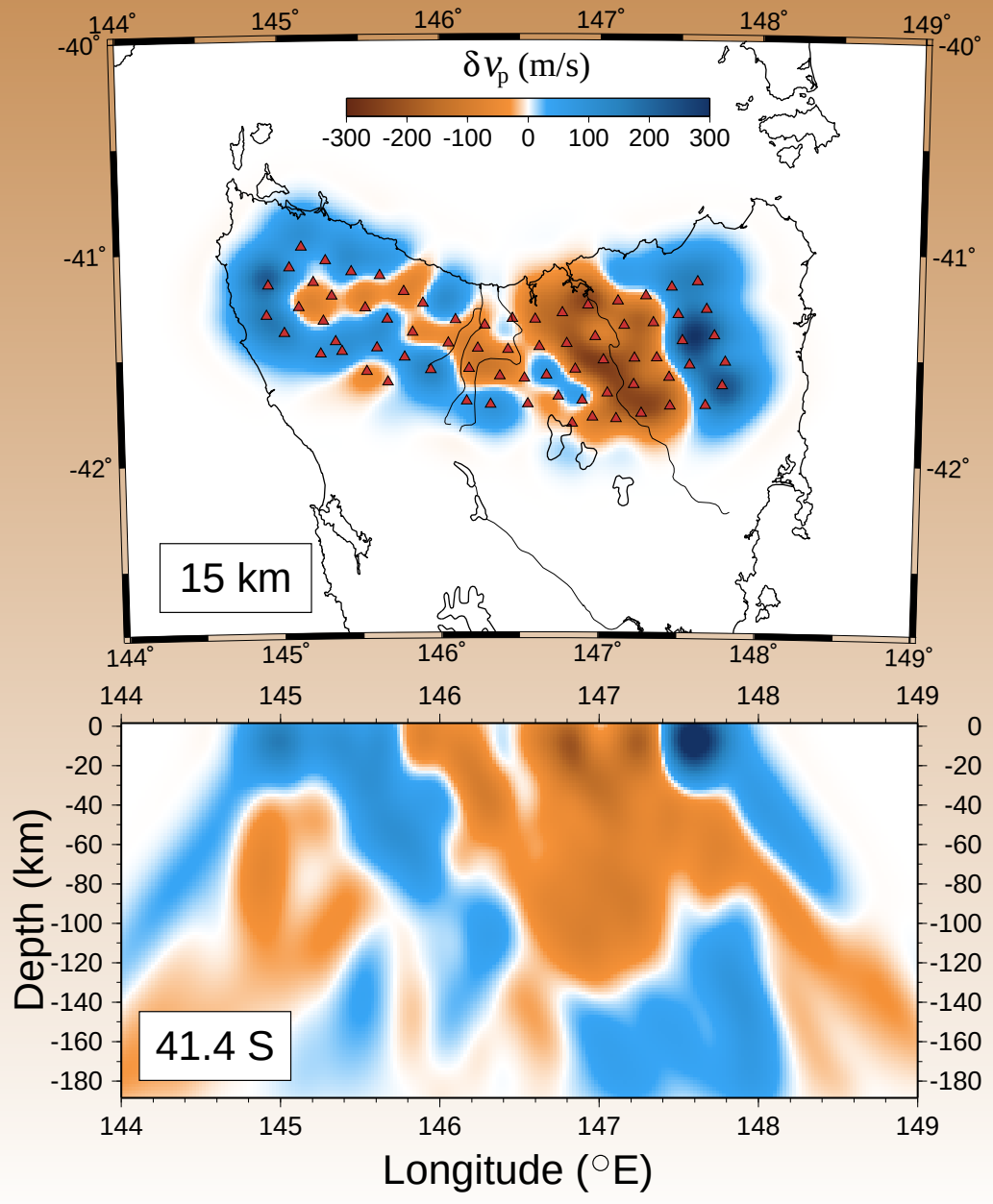
Results from TIGGER and SEAL

The Tasmanian lithosphere



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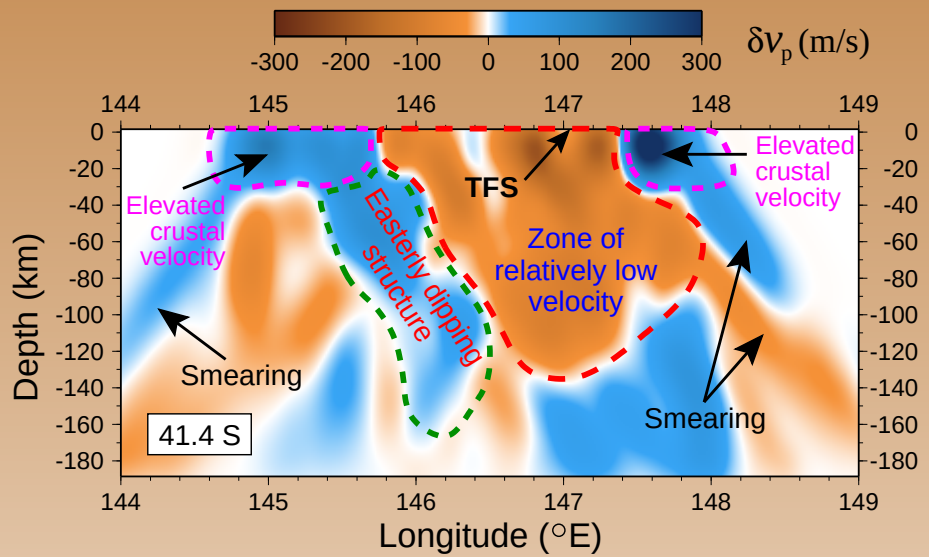

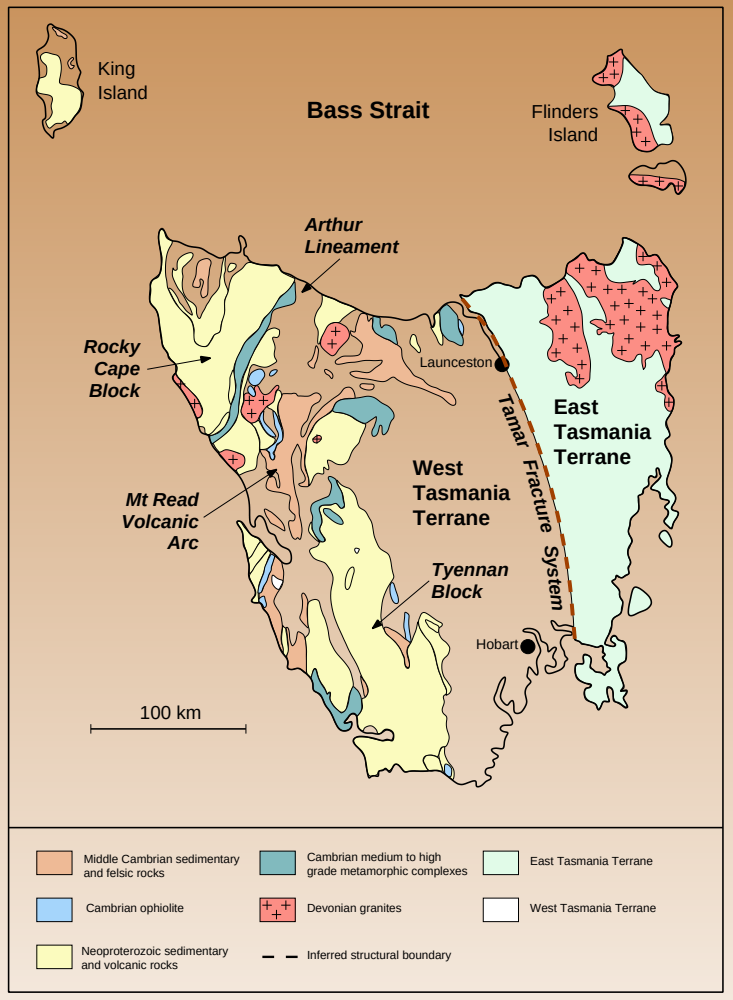

- Proposed TFS does not correspond to wavespeed transition zone.
- Rawlinson *et al.* (2006), *JGR*, **111**.

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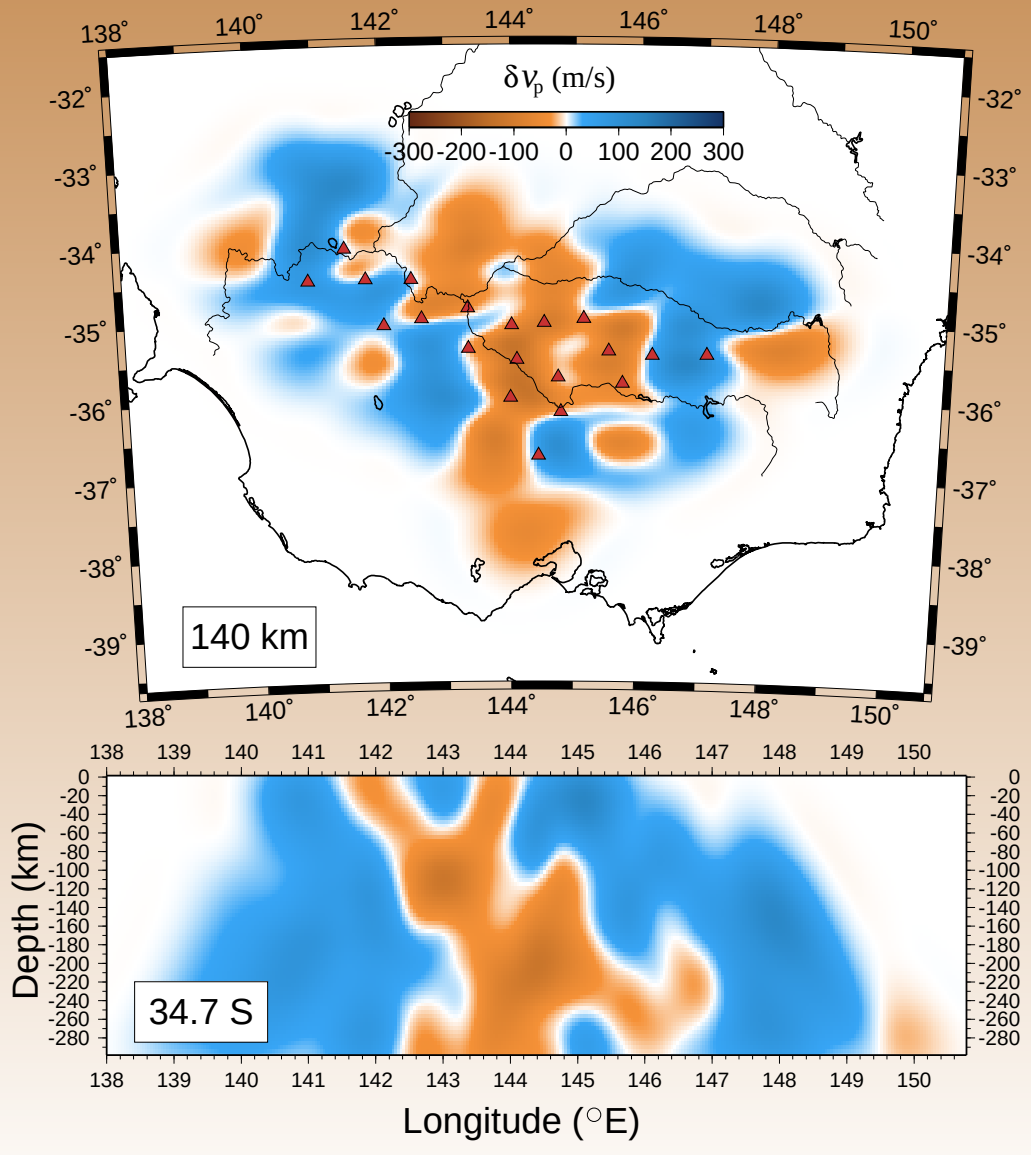
Results from TIGGER and SEAL

Structure beneath the Murray Basin



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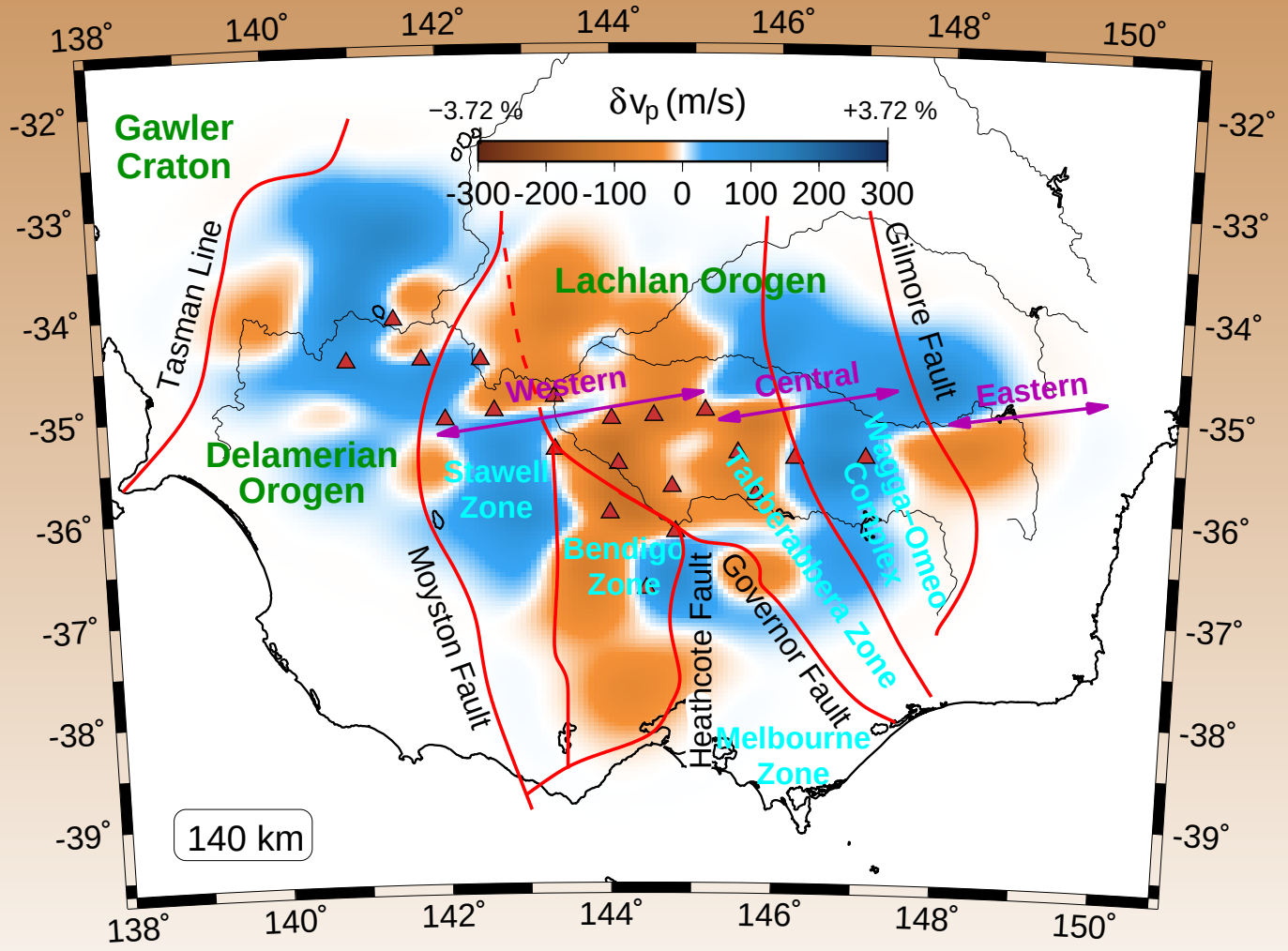

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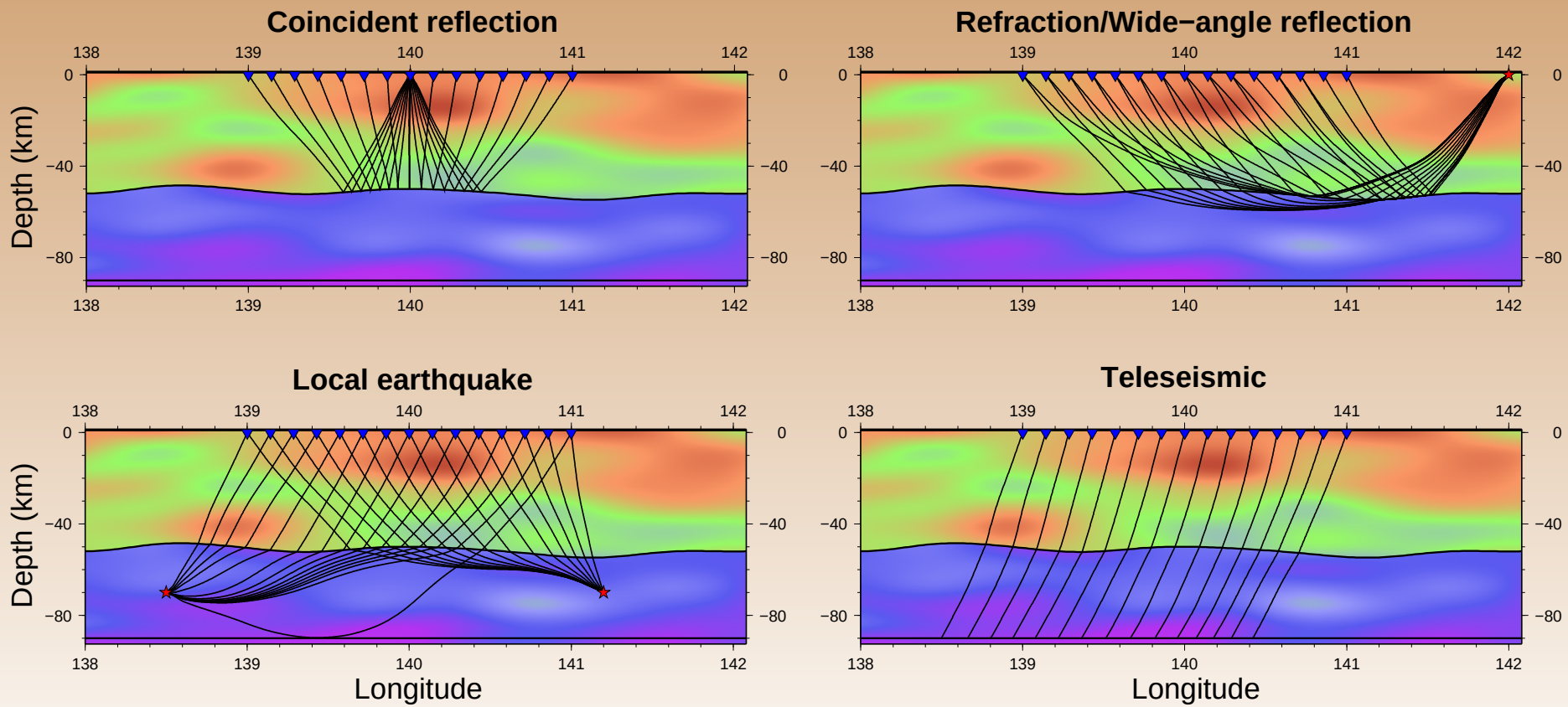
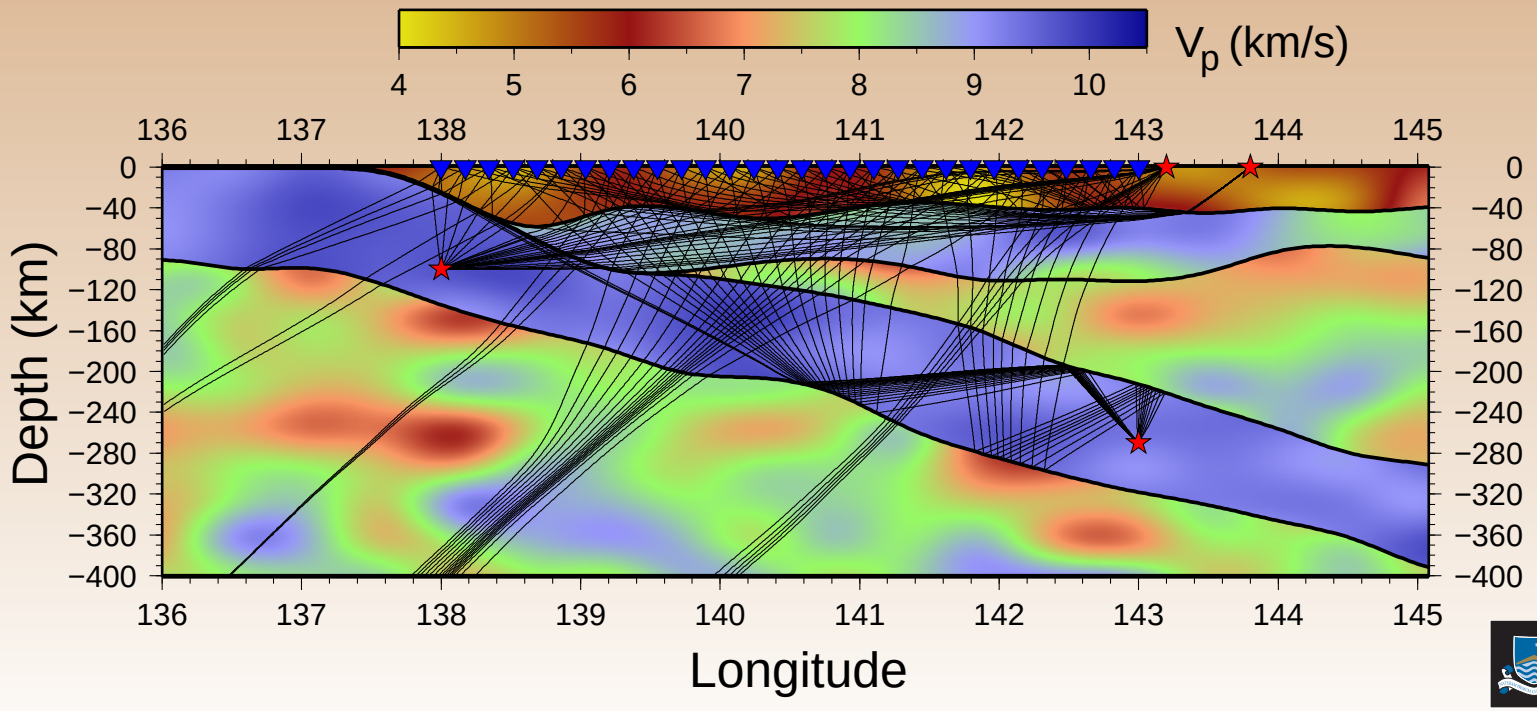
Combining multiple datasets
Common classes of seismic data

- There are several classes of seismic data that are frequently exploited in local-regional scale array studies.



Combining multiple datasets
Common classes of seismic data

- Most tomographic studies deal with a single dataset; however, it is often the case that more than one dataset spans a common region of the Earth.
- A unified inversion should improve structural imaging e.g. resolve both crust and upper mantle features.



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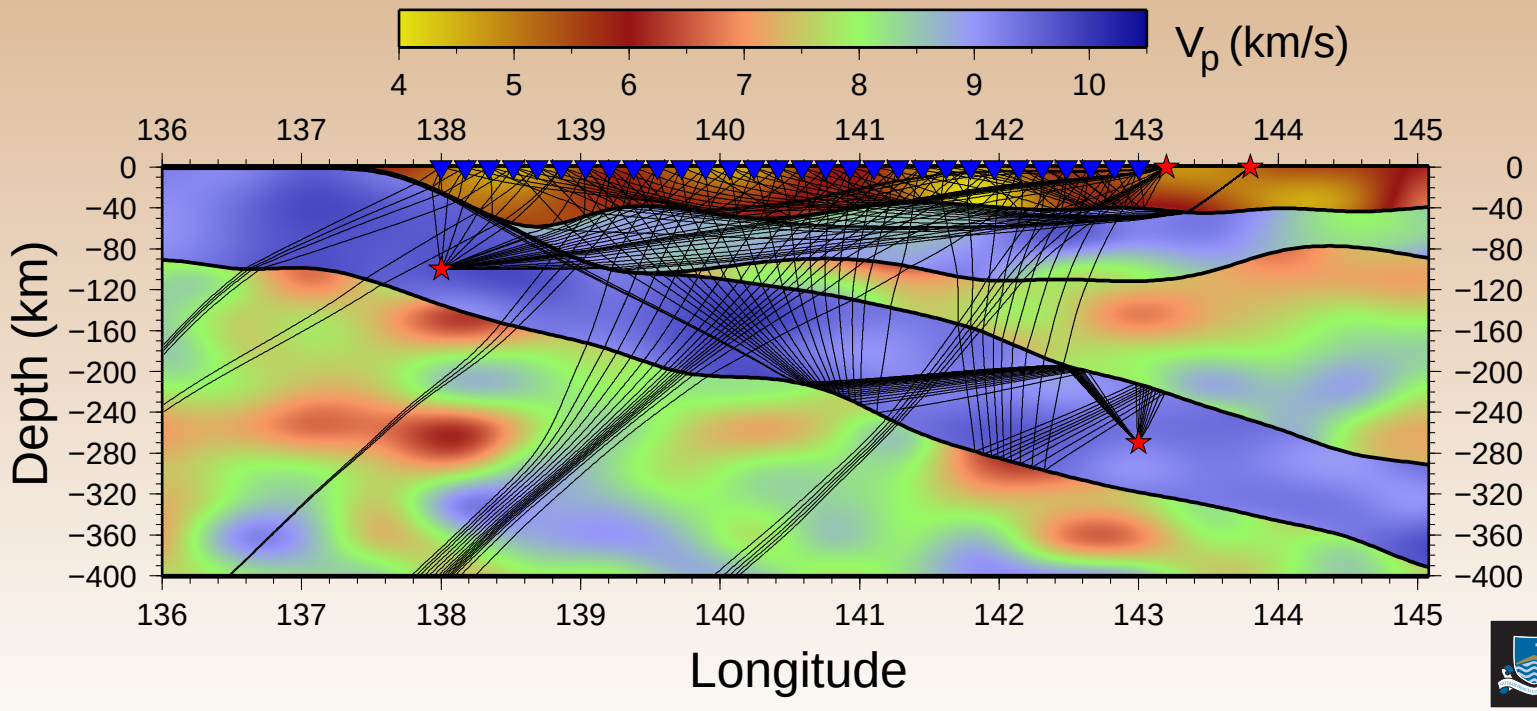
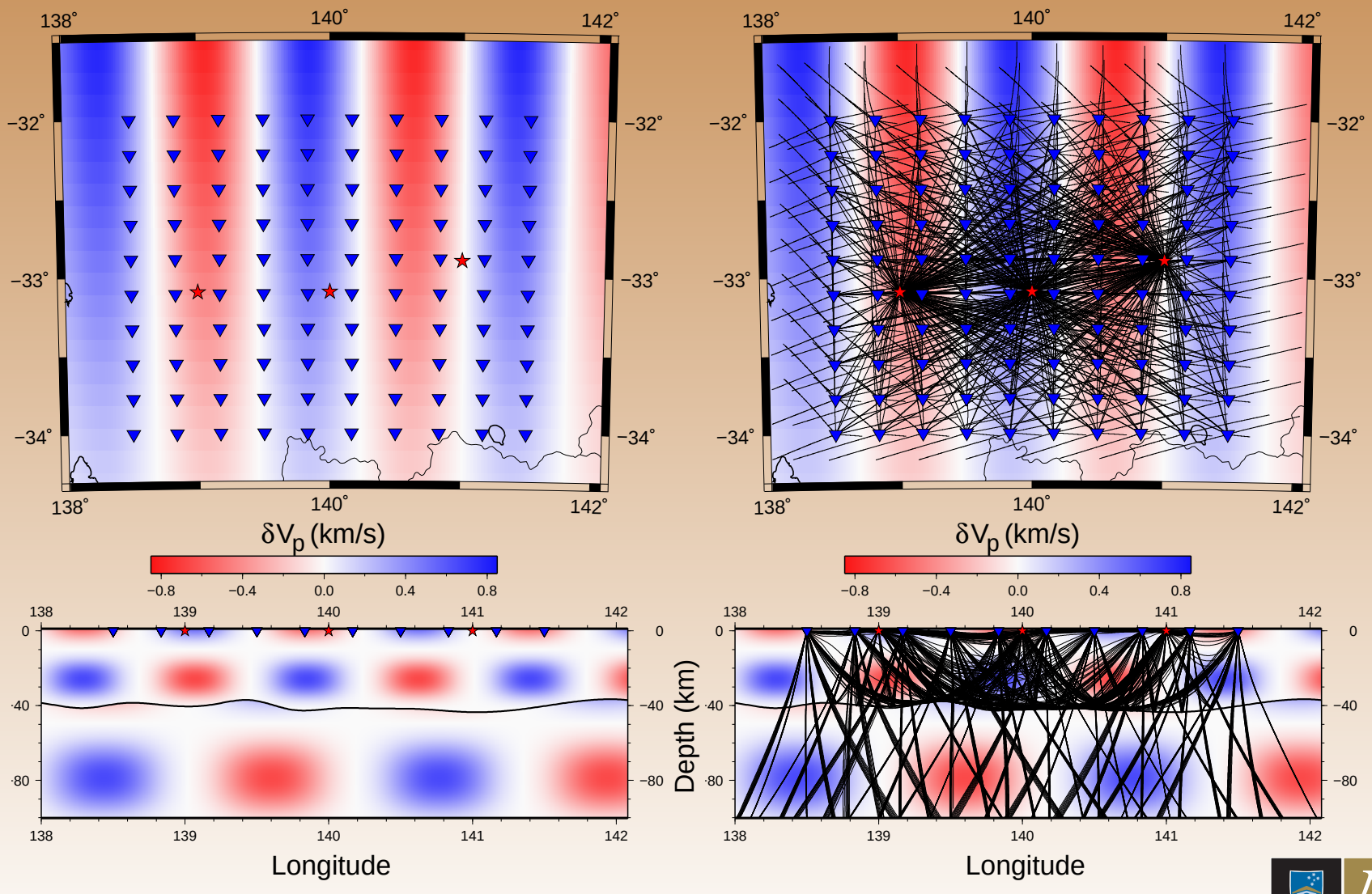


Combining multiple datasets

A robust tomographic inversion scheme



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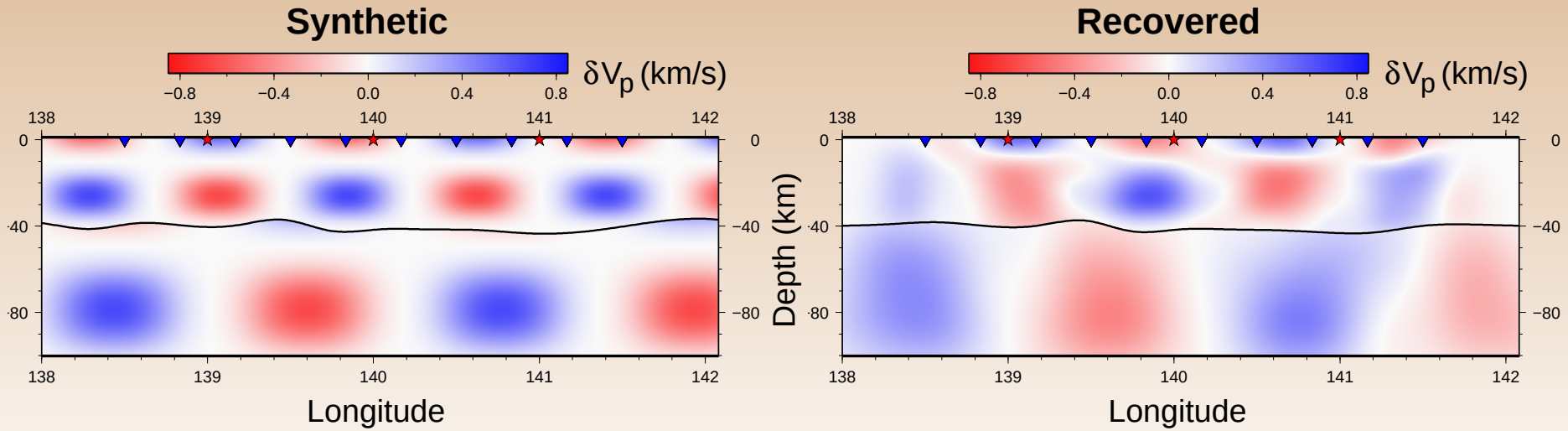
Combining multiple datasets
A robust tomographic inversion scheme

Tomographic method

- Solution computed using iterative non-linear scheme based on sequential application of 3-D FMM scheme and 20-D subspace inversion method.
- The solution below was produced after six iterations with a laterally invariant starting model.



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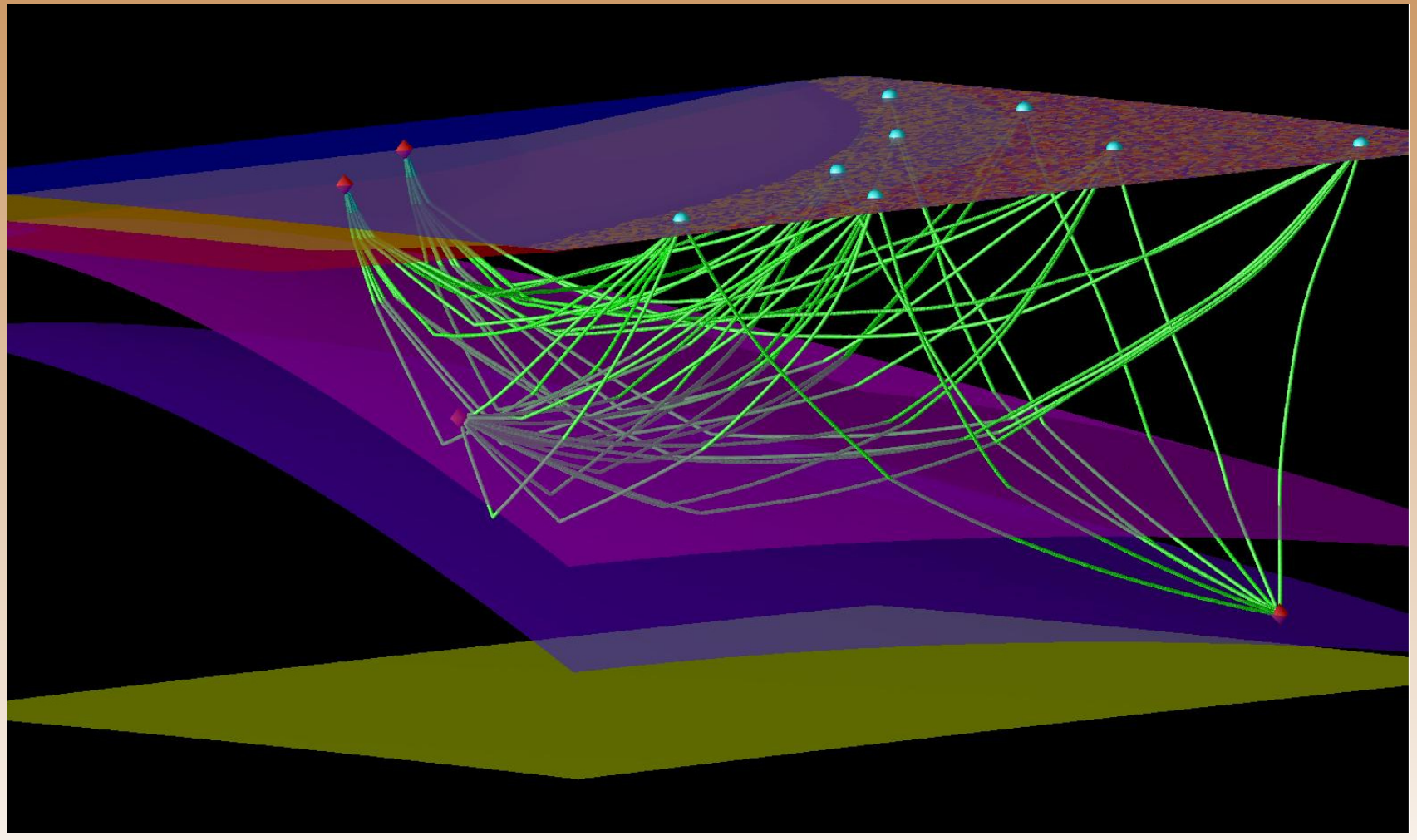

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Overseas analogues
The USArray

- The USArray is part of EarthScope, and involves the systematic deployment of a large mobile seismic array to achieve high density (70 km spacing) continent-wide coverage over a 12 year period beginning in 2004.
- The complete USArray project comprises three elements:
  - A transportable array of 400 portable 3-component broadband seismometers.
  - A flexible component of 400 3-component short period and broadband seismometers plus 2,000 single channel high frequency recorders.
  - A permanent array of 43 3-component seismic stations.
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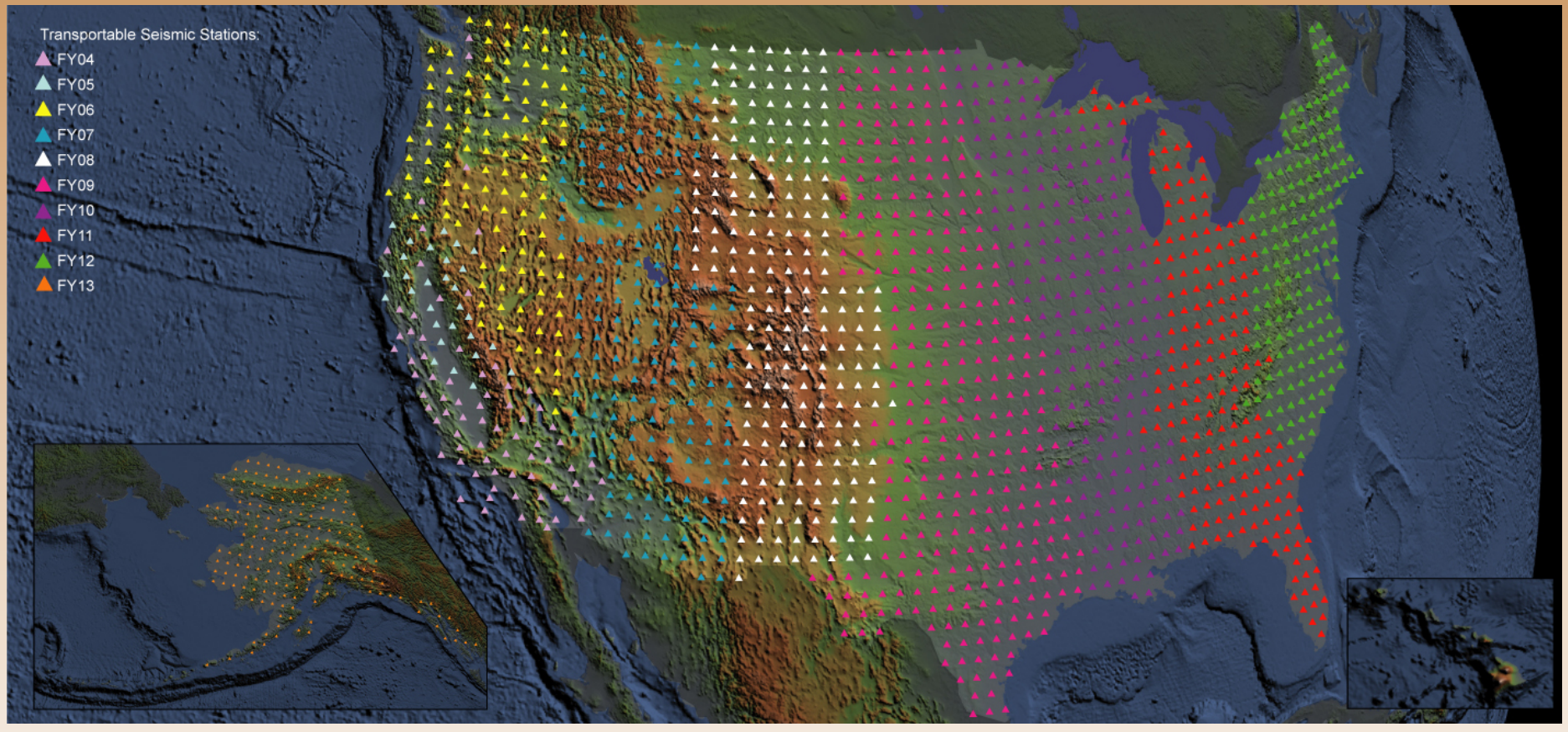

Overseas analogues
The USArray

Year	Transportable (Tb)	Permanent (Tb)	Flexible (Tb)	
1	0.164	0.030	0.158	
2	0.569	0.119	0.979	
3	1.031	0.217	1.847	
4	2.077	0.235	3.867	
5	2.529	0.235	4.210	
6	2.529	0.235	4.210	
7	2.529	0.235	4.210	
8	2.529	0.235	4.210	
9	2.529	0.235	4.210	
10	2.529	0.235	4.210	
Total	**19.015**	**2.011**	**32.111**	**53.137**

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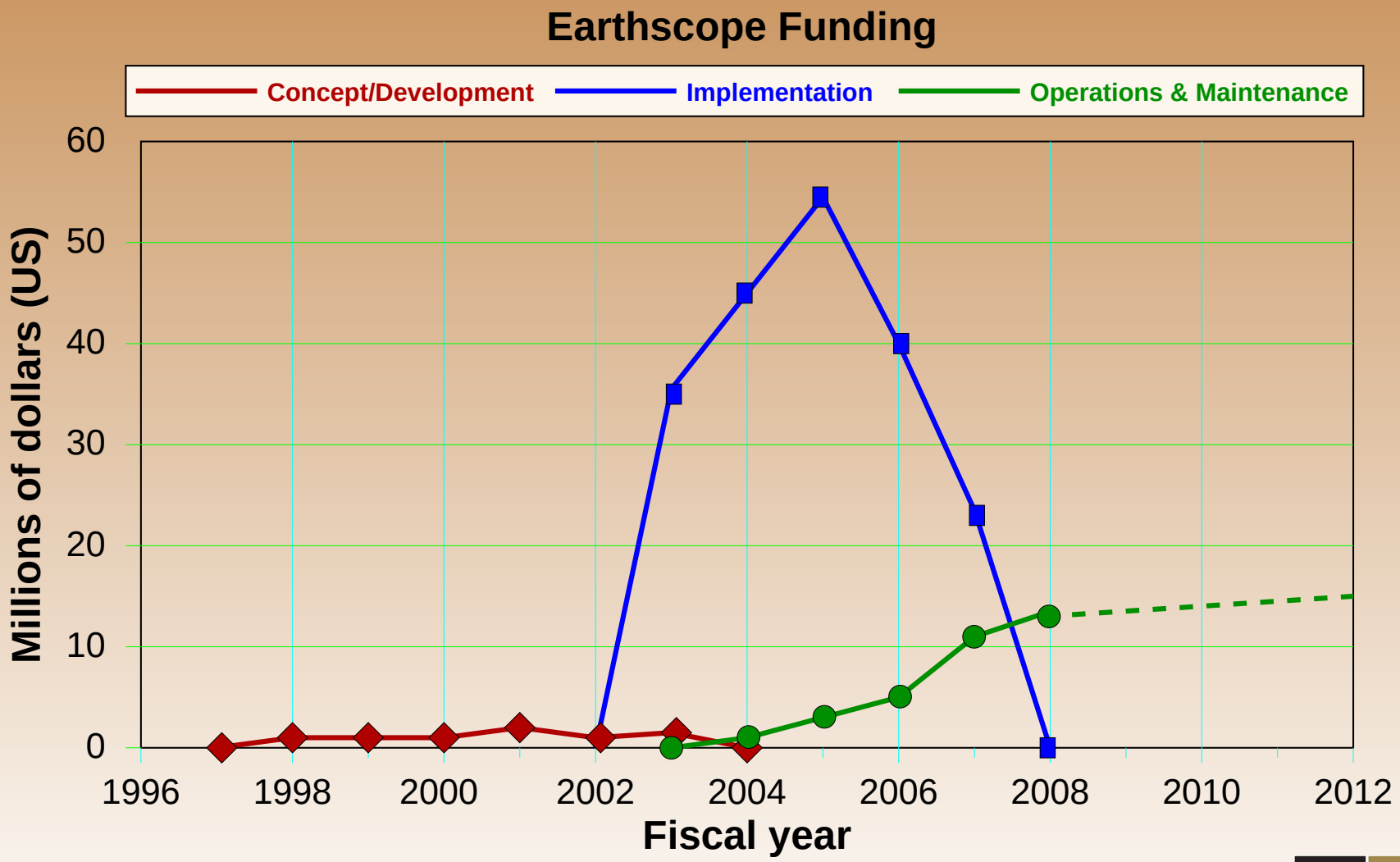

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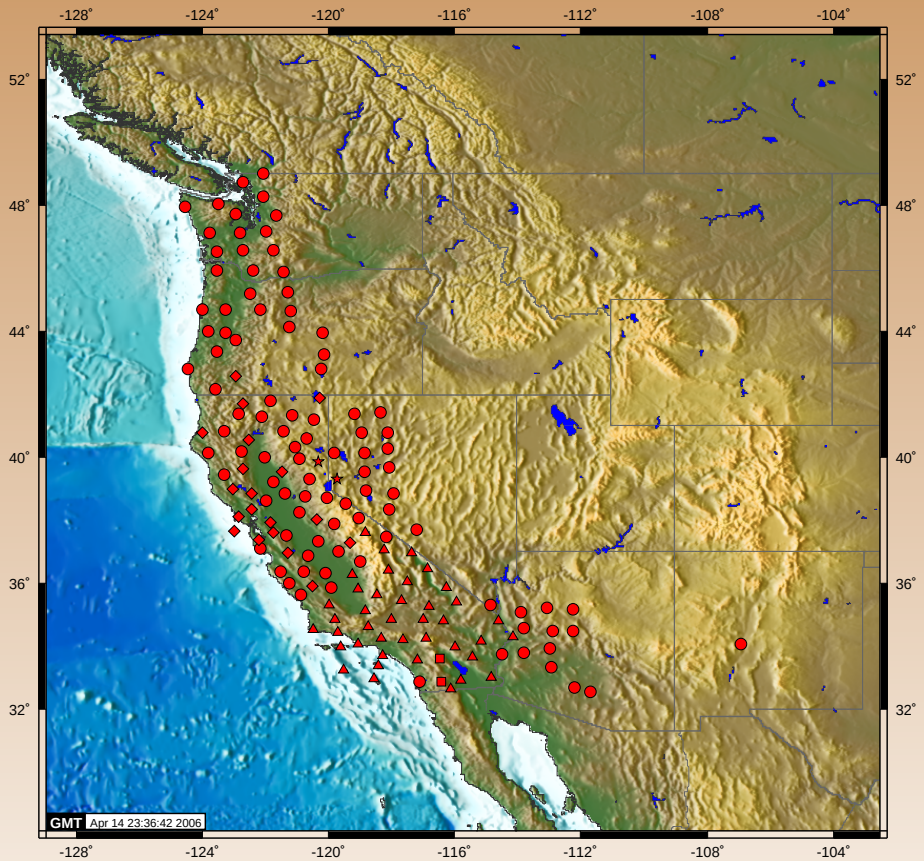

	Data (Tb)	Budget (US$m)	Scientific outcome
USArray	**53.137**	**236.26**	**?????**
AUSarray (short period)	**0.379**	**0.203**	**5+ papers**
Ratio	**140:1**	**1164:1**	**?????**

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