EGU General Assembly 2020

A better strategy for interpolating gravity and magnetic data

Santiago Soler[1,2] and Leonardo Uieda[3]

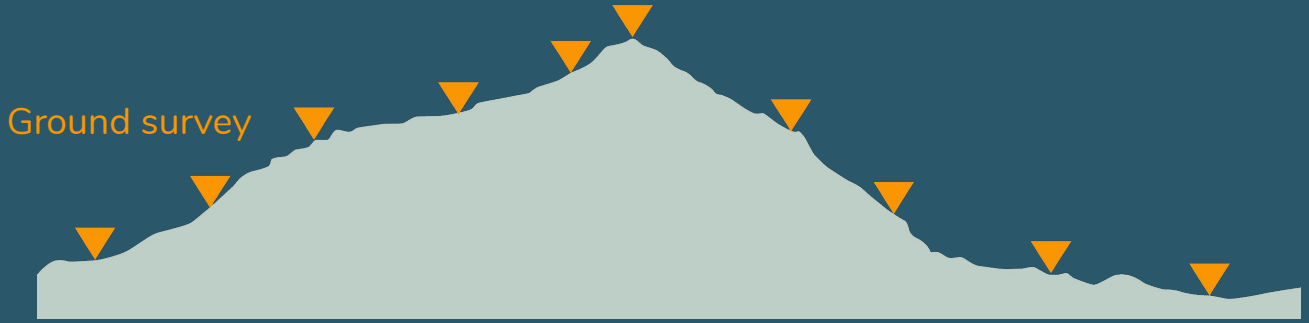
[1] CONICET, Argentina
[2] Instituto Geofísico Sismológico Volponi, UNSJ, Argentina
[3] Department of Earth, Ocean and Ecological Sciences, University of Liverpool, UK

CONICET

COMPUTER-ORIENTED GEOSCIENCE LAB

I.G.S.V.

Gravity and magnetic data



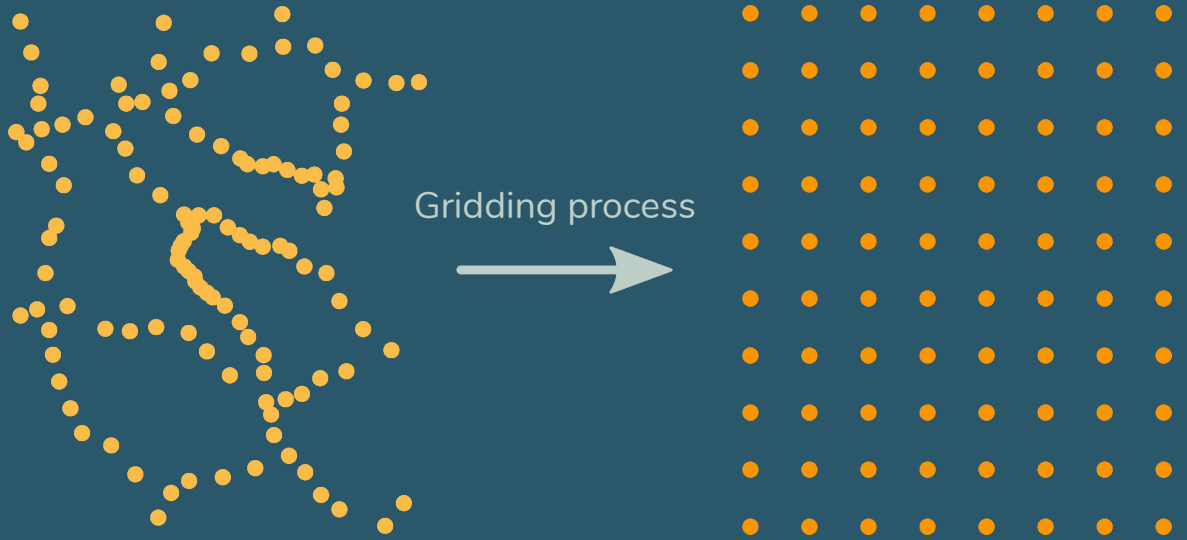
- Above surface
- Irregular paths
- At different heights

What do we know about gravmag data?

Harmonic fields

Depend on height

And... are usually needed in regular grids



All purpose 2D gridders are not the best option

Resulting grid is not harmonic

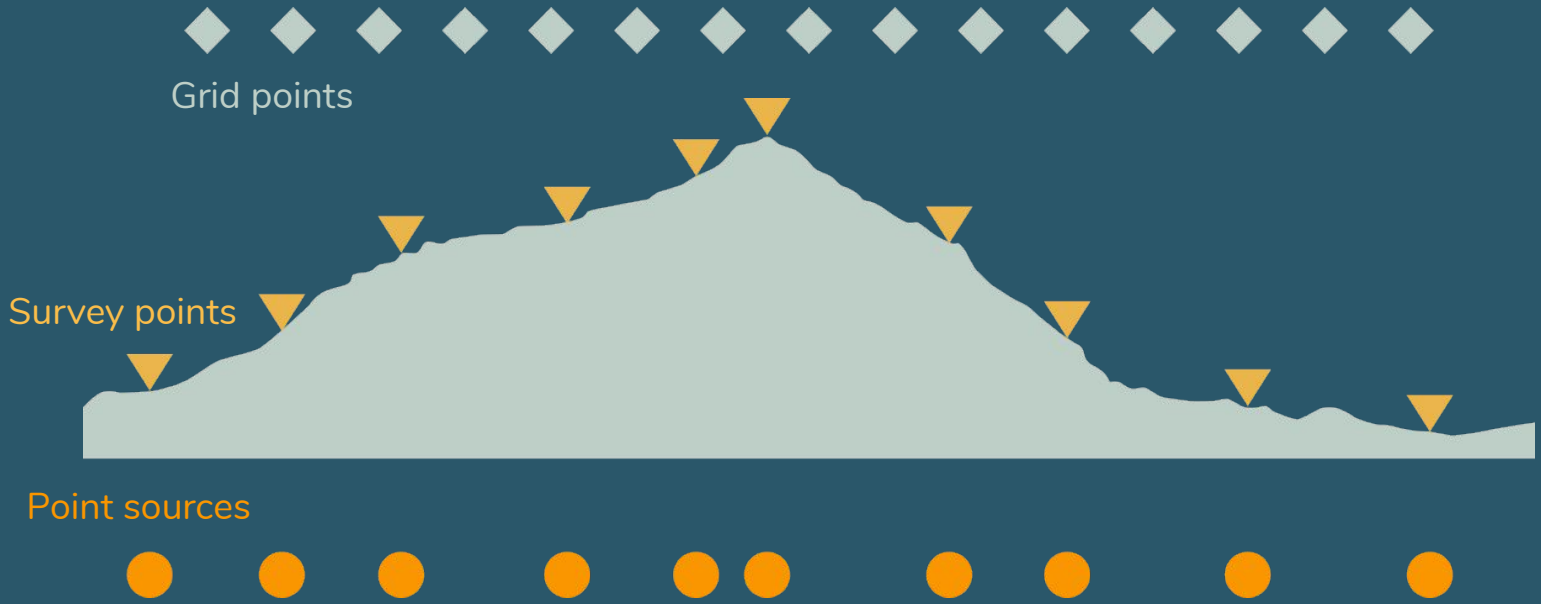
Ignore height dependency

Equivalent Sources

Define a set of point sources that generate the same observed field.

Equivalent Sources

Use the equivalent sources to predict the field on grid points



Advantages of equivalent sources

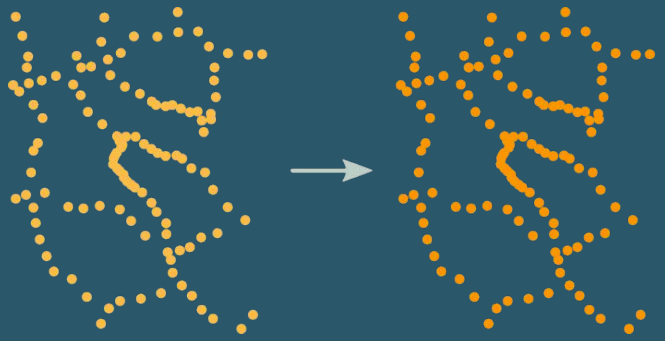
Grid values are harmonic

Consider the observation heights

Where to put the equivalent sources?

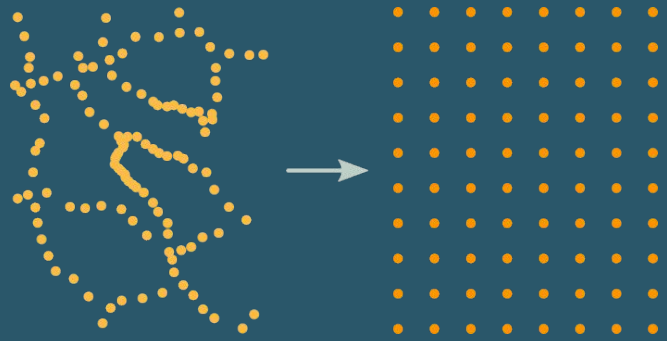
Classical Strategies

Sources below data points



Data points Sources

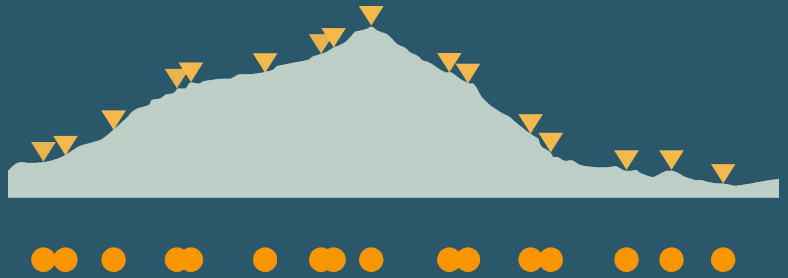
Regular grid of sources



Data points Sources

Classical Strategies

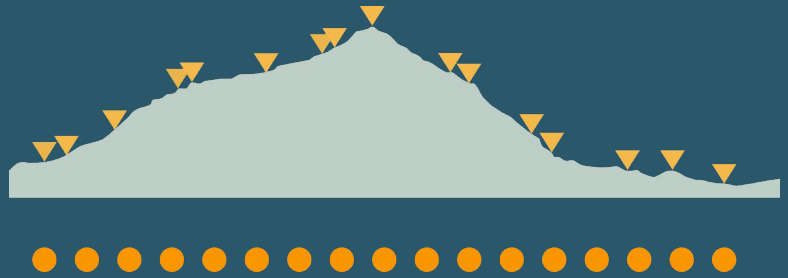
Sources below data points



Disadvantages:

- Could create aliases on anisotropic distribution of sources (e.g. many sources along flight paths).

Regular grid of sources

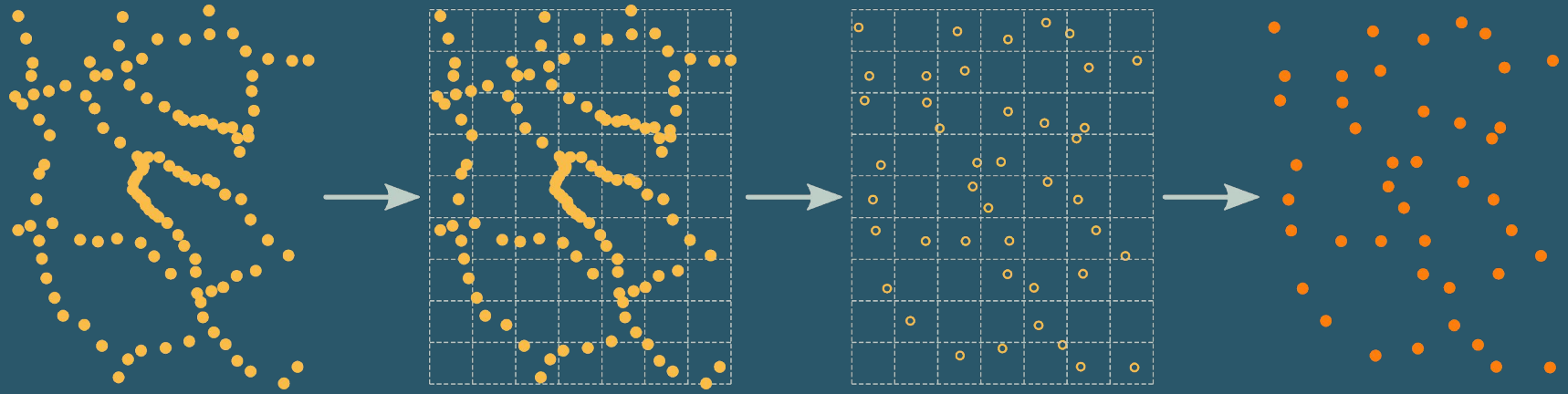


Disadvantages:

- May require too many sources to produce accurate predictions, needing high computational load.

A new strategy

Block-averaged sources



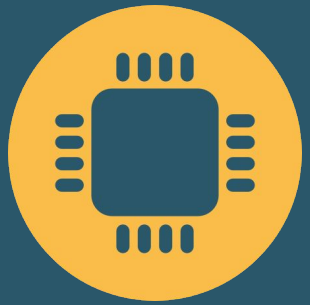
Data points

Divide the region in **blocks** of equal size

Average data coordinates per block

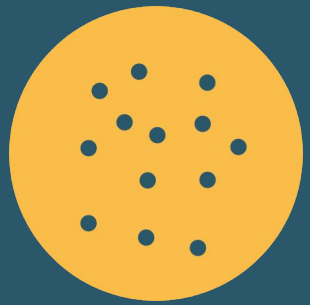
Sources under each averaged location

Advantages of block-averaged sources



Reduces computational load

Reduces the number of point sources

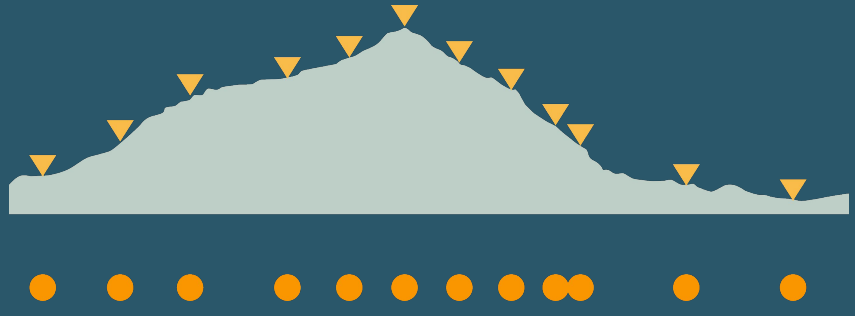


Prevents aliasing

Creates non-anisotropic sources

But… at which depth?

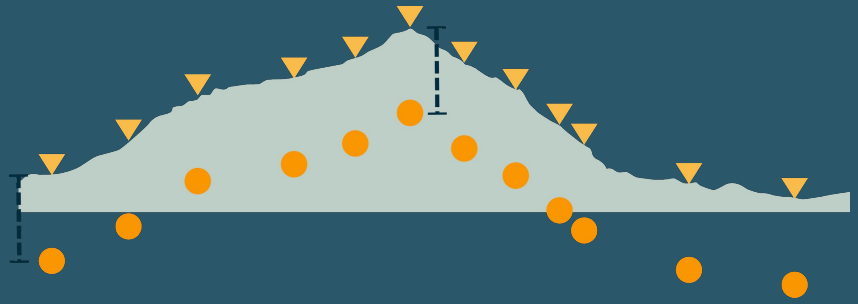
Constant Depth



```
sources_depth = depth
```

All sources at the same depth.

Relative Depth



```
sources_depth = data_height - depth
```

Sources at the same relative depth
from its corresponding data point.

Variable Depth

$$\text{sources\_depth} = \text{data\_height} - \text{depth} - f \cdot \text{distance\_n\_neighbours}$$

mean distance to nearest neighbours

constant factor

Variable Depth

- **Scattered** data produce **deep** sources.
- **Clustered** data produce **shallow** sources.

Source distributions

Combining depth types and source layouts:

	Constant depth	Relative depth	Variable depth
Sources below data	✓	✓	✓
Grid sources	✓	✗	✗
Block-averaged sources	✓	✓	✓

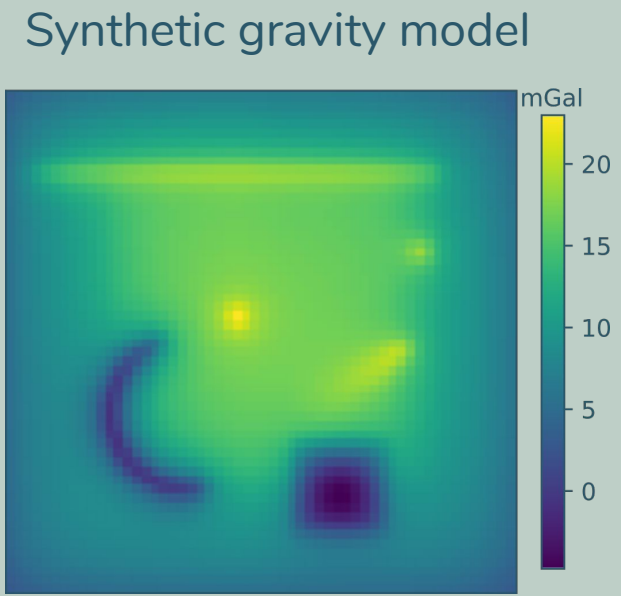
We obtain seven different source distributions.

* **Grid sources** are only compatible with **constant depth**

How good are they?

Comparison of source distributions

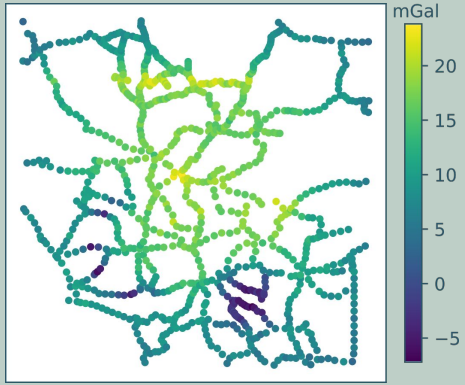
1. Synthetic gravity model



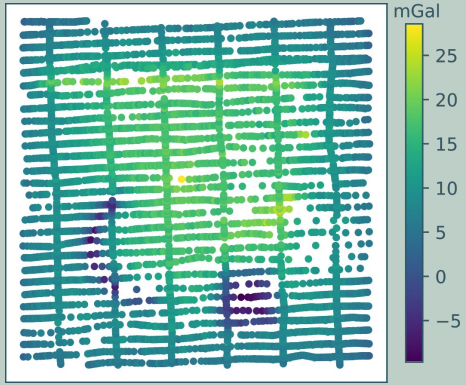
Comparison of source distributions

1. Synthetic gravity model
2. Synthetic surveys

Ground survey

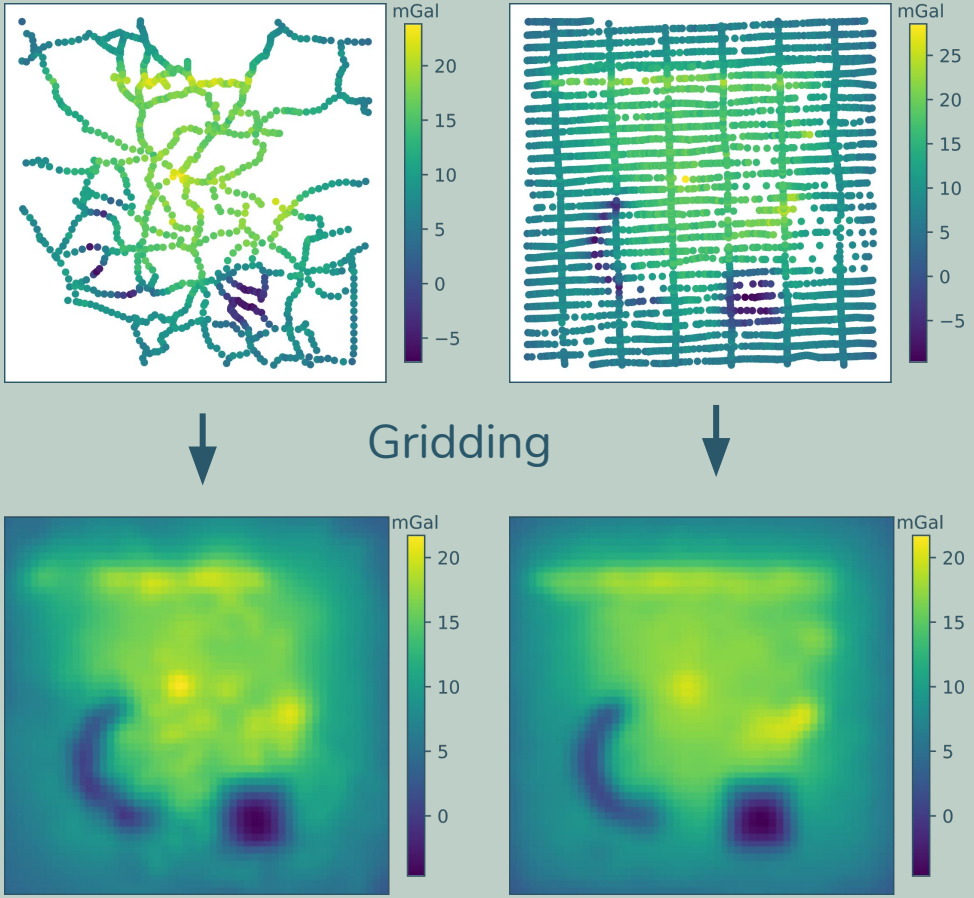


Airborne survey



Comparison of source distributions

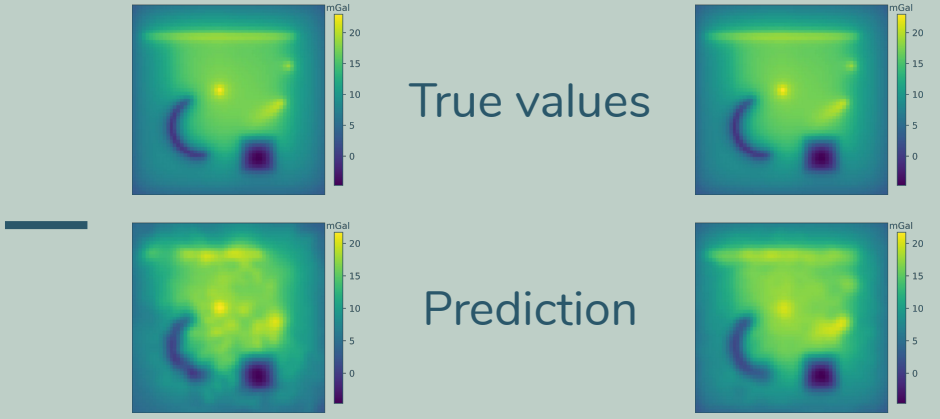
1. Synthetic gravity model
2. Synthetic surveys
3. Grid data with each source distribution



* Obtaining seven grids for each synthetic survey

Comparison of source distributions

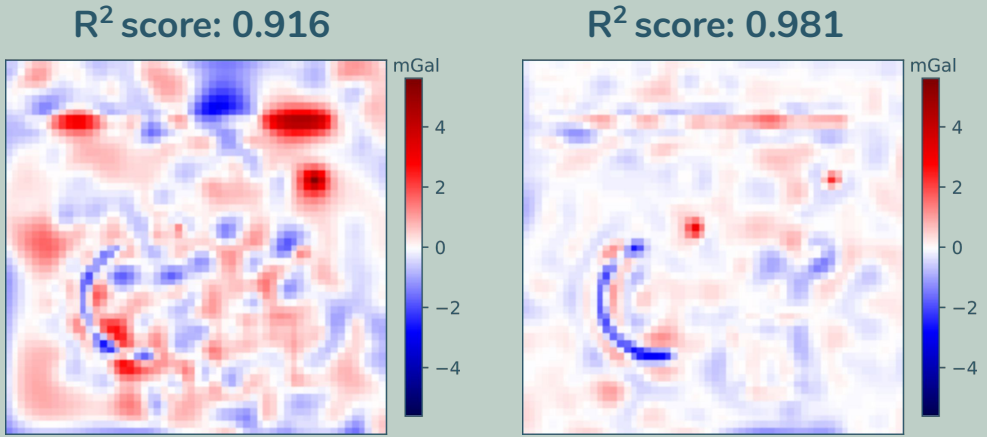
1. Synthetic gravity model
2. Synthetic surveys
3. Grid data with each source distribution
4. Compare against true values



Comparison of source distributions

1. Synthetic gravity model
2. Synthetic surveys
3. Grid data with each source distribution
4. Compare against true values
5. Score the interpolation

Prediction errors



R^2 scores

Ground survey	Constant depth	Relative depth	Variable depth
Sources below data	0.862	0.862	0.878
Grid sources	0.847	-	-
Block-averaged sources	**0.867**	**0.866**	**0.916**

Airborne survey	Constant depth	Relative depth	Variable depth
Sources below data	0.974	0.975	0.975
Grid sources	0.978	-	-
Block-averaged sources	**0.974**	**0.975**	**0.981**

R^2 scores

Ground survey	Constant depth	Relative depth	Variable depth
Sources below data	0.862	0.862	0.878
Grid sources	0.847	-	-
Block-averaged sources	**0.867**	**0.866**	**0.916**

Airborne survey	Constant depth	Relative depth	Variable depth
Sources below data	0.974	0.975	0.975
Grid sources	0.978	-	-
Block-averaged sources	**0.974**	**0.975**	**0.981**

All **source distributions** achieve **accurate interpolations**

R^2 scores

Ground survey	Constant depth	Relative depth	Variable depth
Sources below data	0.862	0.862	0.878
Grid sources	0.847	-	-
Block-averaged sources	**0.867**	**0.866**	**0.916**

Airborne survey	Constant depth	Relative depth	Variable depth
Sources below data	0.975	0.975	0.975
Grid sources	0.978	-	-
Block-averaged sources	**0.974**	**0.975**	**0.981**

All **source distributions** achieve **accurate interpolations**

Variable depth produce slightly **better results**

But... how many sources do they use?

	Ground survey	Airborne survey
Sources below data	963	5673
Grid sources	1444	6162
Block-averaged sources	518	1663

But... how many sources do they use?

	Ground survey	Airborne survey
Sources below 0	906	5673
Grid sources	1	6162
Block-averaged sources	518	1663

Block-averaged distribution creates **less sources**

Conclusions

- New strategy for gridding: block-averaged sources.
- Produces accurate interpolations, comparable with classical strategies.
- Create less sources, requiring less computational load.
- May help solving aliasing problems.
- Using a variable depth may give more accurate results.

Acknowledgements

Fatiando a Terra

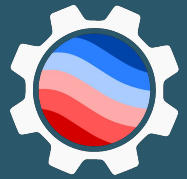
Open-source Python tools for Geophysics

www.fatiando.org

This research was possible thanks to the work of developers and maintainers of open-source software.

Want to read more about this?

Article and code will be released soon... stay tuned:



COMPUTER-ORIENTED
GEOSCIENCE LAB

https://www.compgeolab.org/

Slides are available for download:

https://doi.org/10.6084/m9.figshare.12217973

All content under
Creative Commons Attribution 4.0