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Outlier detection in relative gravimetric networks

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1. Objectives of the study

A method based on Least-Squares Collocation (LSC) was designed with the following goals:

- To estimate the **accuracy** of relative gravimetric networks.
- To detect **outliers** in gravimetric networks of Argentina.

2. The LSC method and its advantages

- Useful for estimating anomalies in arbitrary points given known anomalies at discret nearby points.
- The estimation is optimal with the least-squares criterion.
- **Problem**: the **spatial covariances** between known and unknown points must be previously known.

$$\Delta g_P = \underbrace{C_{Pi} C_{ik}^{-1}}_{\text{Empirical covariance matrices}} \Delta g_k$$

Unknown point anomaly — Known anomalies

3. The covariance function

The covariance function (CF) is not known *a priori*, and should therefore be estimated via a model if LSC is to be used (variance, correlation length are obtained).

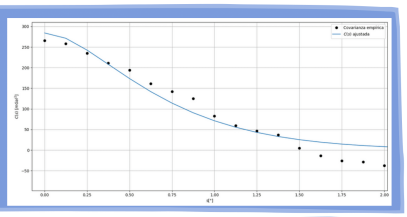

Figure 1: empirical CF (black dots) plotted along with adjusted FC (blue line).

4. Accuracy estimation

1. Obtain CF parameters.
2. Randomly select half of the data points (**control points**)
3. Use control points to obtain interpolated anomalies at remaining points (**validation points**).
4. Calculate difference between interpolated anomalies and observed anomalies at validation points.
5. Accuracy of the data set is estimated as the variance of the differences.

5. *Outlier* detection

The criterion used in Vergos et al., 2005 was applied:

$$|\Delta AB_P| > k\sqrt{\sigma^2(\Delta AB_P) + \sigma_P^2}$$

Validation - control point difference. — Estimadted accuracy — Observation error in AB.

If criterion is met, the observation at P is an *outlier*.

6. Application to a specific network

Data set

1888 points corresponding to the **Argentinean Gravimetric Network** in Buenos Aires.

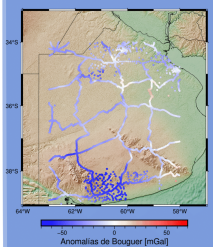

Figure 2: distribution of the Bouguer anomalies in Buenos Aires province.

Accuracy estimation

With *outliers*:

$$< \Delta AB_P >= 0.12\ mGal$$
$$\sigma(\Delta AB_P) = 3.16\ mGal$$

Without outliers:

$$< \Delta AB_P >= 0.08\ mGal$$
$$\sigma(\Delta AB_P) = 2.31\ mGal$$

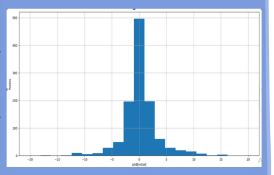

Figure 3: histrogram of differences between interpolated and observed Bougher anomalies.

7. Results

A total of 37 outliers detected (1.9% of total data set). After removing outliers, the accuracy improved from 3.16 to **2.31 mGal**.

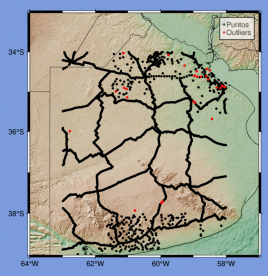

Figure 4: map containing data distribution (black dots) and outliers that satisfy the Vergos criterion (red dots).