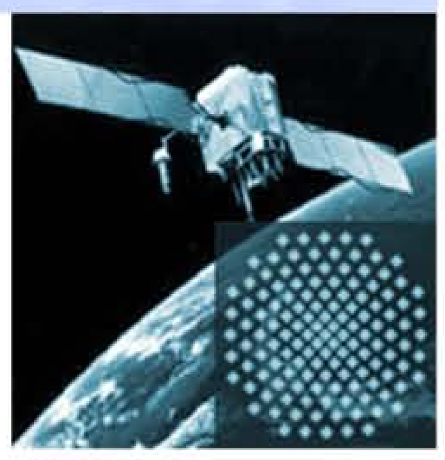
Representation of Regional Gravity Fields by Radial Base Functions



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Abstract

The research aims at an investigation of the optimal choice of local base functions to derive a regional solution of the gravity field. Therefore, the representation of the gravity field is separated into a global and a residual signal, which includes the regional details. To detect these details, a localizing radial base function with a few parameters is developed. The observations of a few residual gravity fields are simulated by orbit integration and the energy-balance technique, in order to test the current approach. After selecting a region of interest, the parameters of the base functions are estimated. In order to get the optimal positions, two searching algorithms are compared.

1. Residual gravity field

THE representation of the global gravity field can be separated into a global and a residual signal. The global signal is modelled by a series of spherical harmonics up to a certain degree N, whereas the local details $\Delta T(\lambda, \theta, r)$ are represented by a superposition of local radial base functions and an omission signal:

$$T(\lambda, \theta, r) = \frac{GM}{R} \sum_{b=0}^{B} \left(\frac{R}{r}\right)^{n+1} \psi(\varpi, \lambda_b, \theta_b, \sigma_b, \eta_b) + \delta T(\lambda, \theta, r).$$

- $\psi(...)$ local base function, developed by a rotation of $\psi^0(...) := \sum_{n=0}^{\infty} \sigma_n P_n(\cos\theta)$ to a new pole (λ_b, θ_b)
- η_b scale factor
- σ_b shape parameter
- ϖ spherical distance between the point (λ, θ) and the pole of the base function
- $\delta T(\lambda, \theta, r)$ omission signal, which cannot modelled by the base functions

2. Simulation of the observations

THE global field is represented by EGM96, and the residual field is generated by a small number of buried masses. Synthetic potential observations are simulated by integration of a CHAMP-orbit and the energy-balance technique for one month. By calculation the difference of the potential with and without the buried masses a residual signal is produced. Then the data is selected for one region of interest (North America).

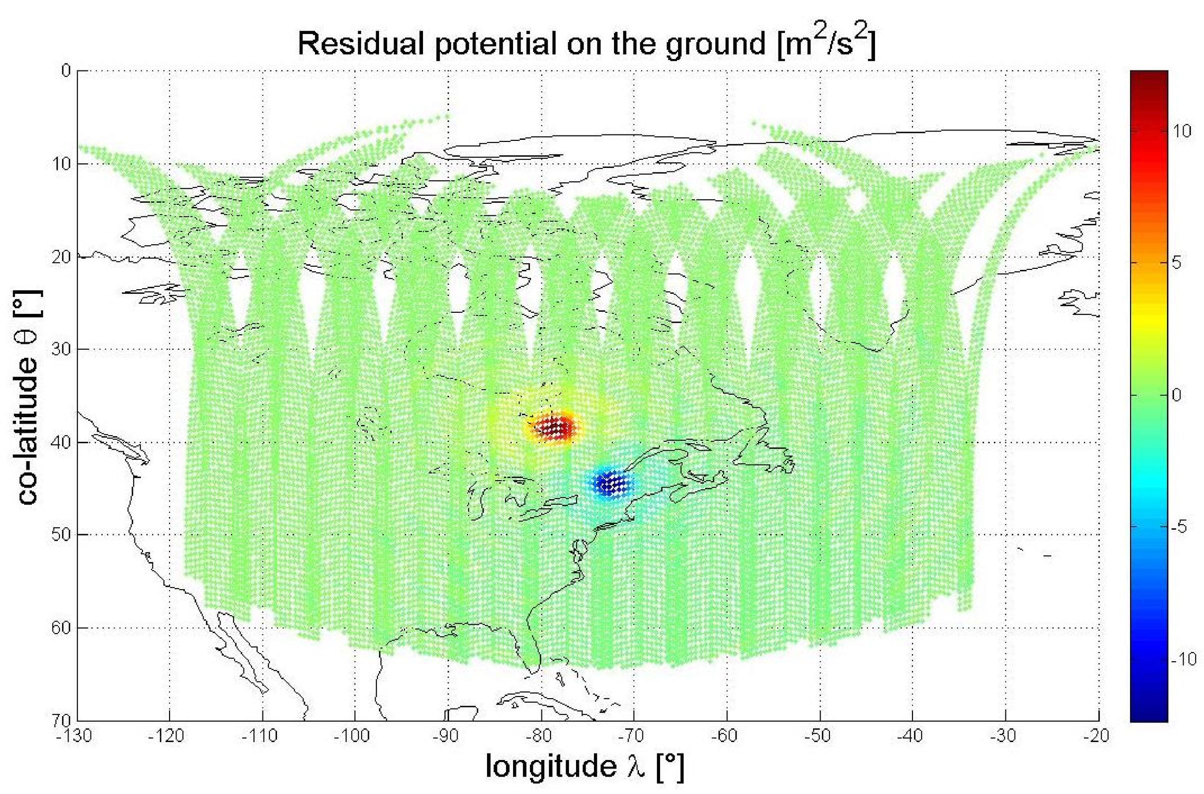

Figure 1: *Simulated potential values of the residual field on the ground*

3. Methodology

IN the following estimations the shape parameter σ_b are fixed. The aim is to optimize the other parameters of the base functions, especially the positions. Therefore two methods are used:

searching grid (SG)

- choosing of a grid of base functions
- estimation of scale factors with fixed positions

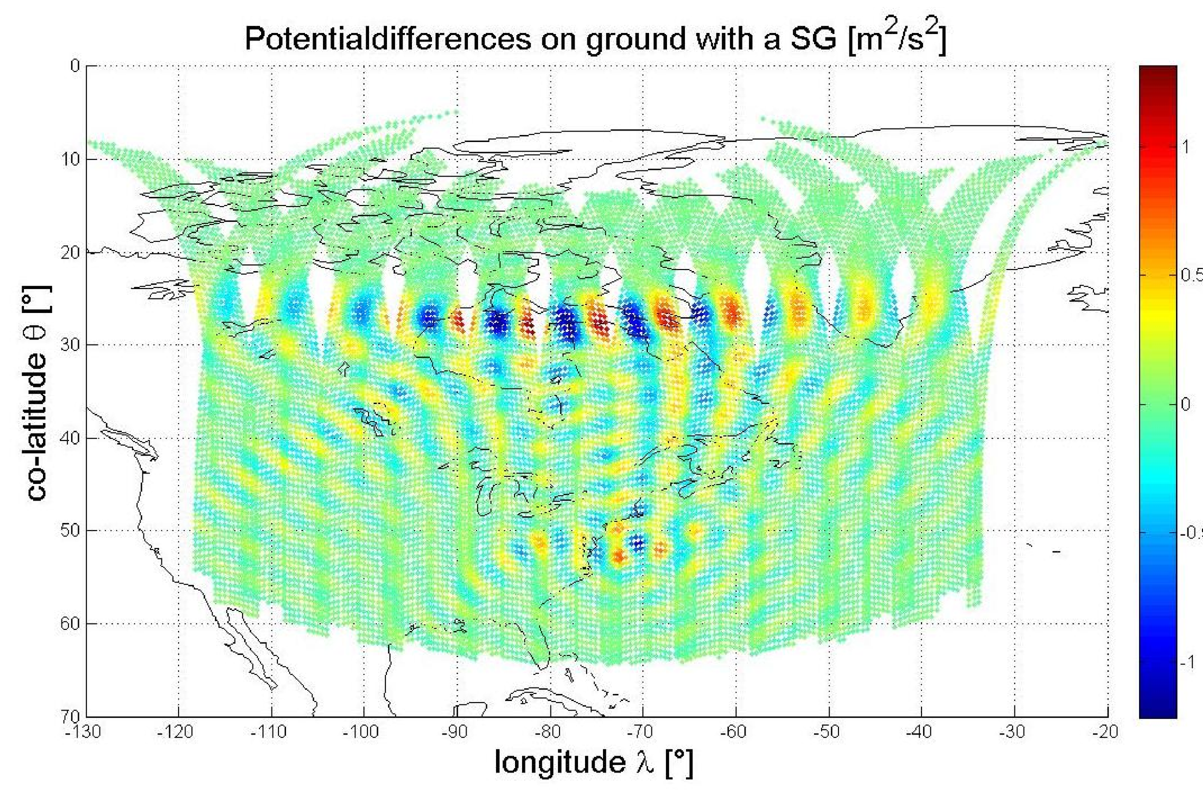

Figure 2: *Difference between the simulated and the estimated potential on the ground after using a searching grid with 182 base functions*

iterative search algorithm (ISA)

In this approach a new base function is added in every iteration:

- searching the localization of the extrema in the residual signal
- transform them to a constant orbit height by a harmonic polynomial
- use the coordinates of the extrema in the polynomial for initial position (λ^0, θ^0) of the base function
- subtracted the estimated potential for one base from the residual signal
- iteration until a termination condition (number of iterations, distance between positions, quotient of scale factors,...) is satisfied
- estimation of scale factors and coordinates by using the gradients of the positions in the adjustment

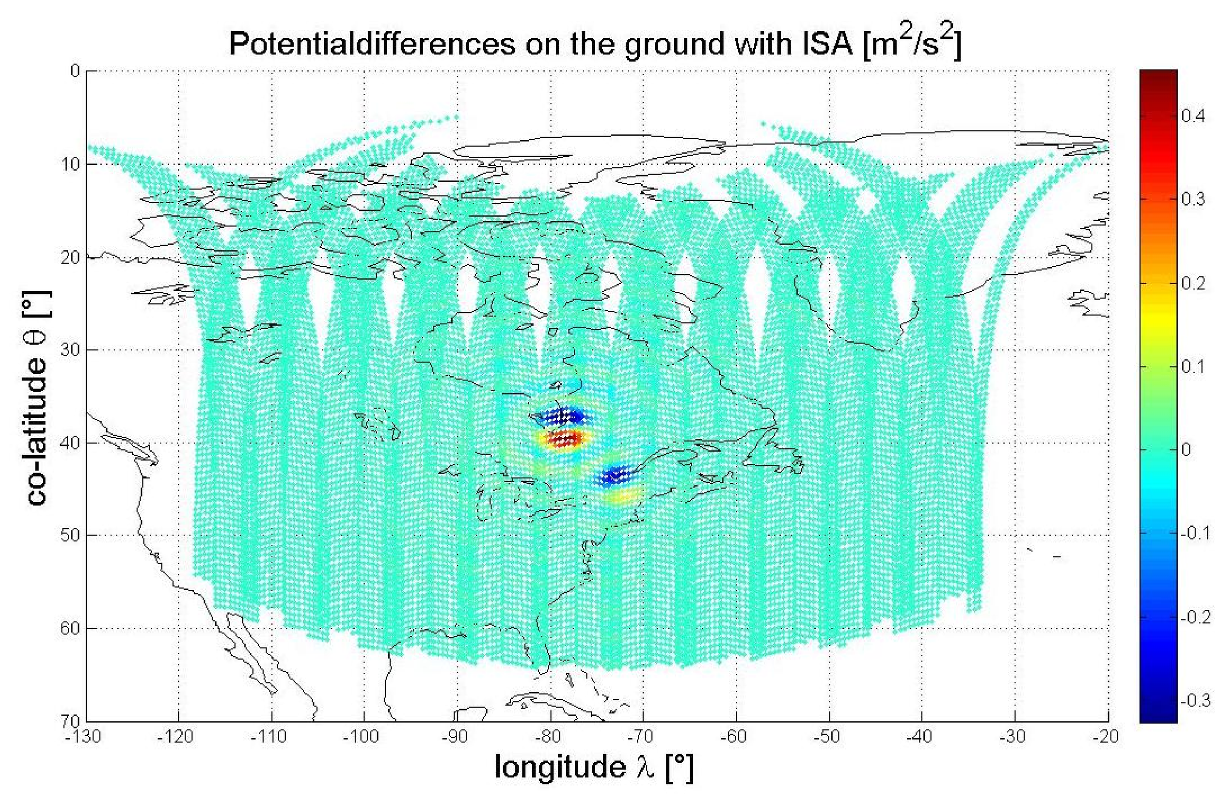

Figure 3: *Difference between the simulated and the estimated potential on the ground after using ISA*

4. Results

IN this example the iterative search algorithm is three times faster as the searching grid resolution (40 min vs. 200 min) and reduces the artificial effects produced by "'wrong localization"'. By using the distances in the termination conditions an ill conditioned matrix can be avoided in the ISA, which is not guaranteed for narrow grids.

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