A GENETIC ALGORITHM APPROACH TO ESTIMATE GLACIER MASS VARIATIONS FROM GRACE DATA

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METHODOLOGY
- Regional gravity field representation using point masses
- Parameter estimation and regularization by means of GA-optimization

REPRESENTATION AND FUNCTIONAL MODEL
- Point masses are represented by
  \[ V(r) = 4\pi G \sum_i \frac{1}{||r - r_i||} m_i \]
  The unknown coefficients \( m_i \) form the parameter vector \( x \) in the Gauss-Markov model \( Ax = y + e \).
- The problem is ill-posed, and hence (Tikhonov) regularization is applied
  \[ \hat{x} = (A^T P A + \alpha I)^{-1} A^T P y \]
  The covariance matrix of the estimated parameters is given by
  \[ \Sigma_x = (A^T P A + \alpha I)^{-1} (A^T P A)^{-1} \sigma^2 \]

GENETIC ALGORITHM OPTIMIZATION
- Minimization of the L2-norm of the residuals \( e \) can also be regarded as an optimization problem
  \[ F(x) = e^T Pe + \alpha x^T x \rightarrow \min_x \]

A two-step procedure is used:
1. GA to estimate point masses by minimizing \( F(x) \)
2. GA to estimate regularization \( \alpha \) to reproduce the solution from step 1

From step 2, optimally regularized parameters \( x \) as well as variance-covariance information \( \Sigma_x \) is obtained.

SUMMARY AND OUTLOOK
The regional representation of the time-variable gravity field by means of point masses is the basis for this study. By reformulating the mass inversion process in terms of an optimization problem, the selection of a suitable regularization parameter can be achieved using genetic algorithms (GA).

The procedure has been applied to the assessment of mass trends in various glacier regions. Comparison with an alternative inference method (spherical harmonics) showed that the proposed methodology is appropriate for this application. Future investigations will focus on removing other non-glaciological signals from the trend estimates by utilizing regional and global hydrological models.

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