High-latitude local gravity field recovery from CHAMP with least-squares collocation

GEOMATICS ENGINEERING

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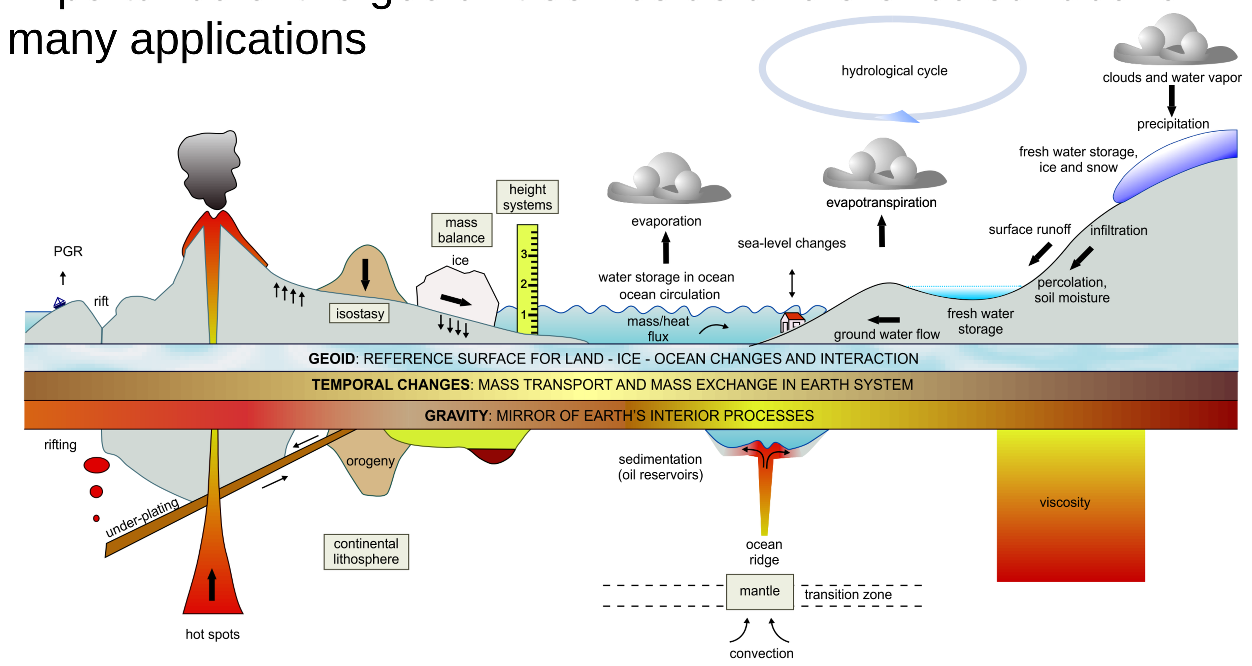
Summary

The poster describes the local gravity field determination for high-latitude areas by means of the energy integral approach. Point-wise data is interpolated by least-squares prediction at satellite height and the results are on the same level as a global solution for good and poor ground coverage. A local solution including downward continuation by least-squares collocation yields same accuracy for good ground coverage as a global solution and improved results for months with poor groundtrack.

Introduction

- Determination of monthly gravity field solutions from the CHAMP satellite mission
- Principle of high-low satellite-to-satellite tracking
- Pointwise determination enables
  1. global solutions, e.g., by spherical harmonic analysis on the sphere or on the torus
  2. local solutions, e.g., by least-squares prediction/collocation
- Importance of the geoid: it serves as a reference surface for many applications



Method

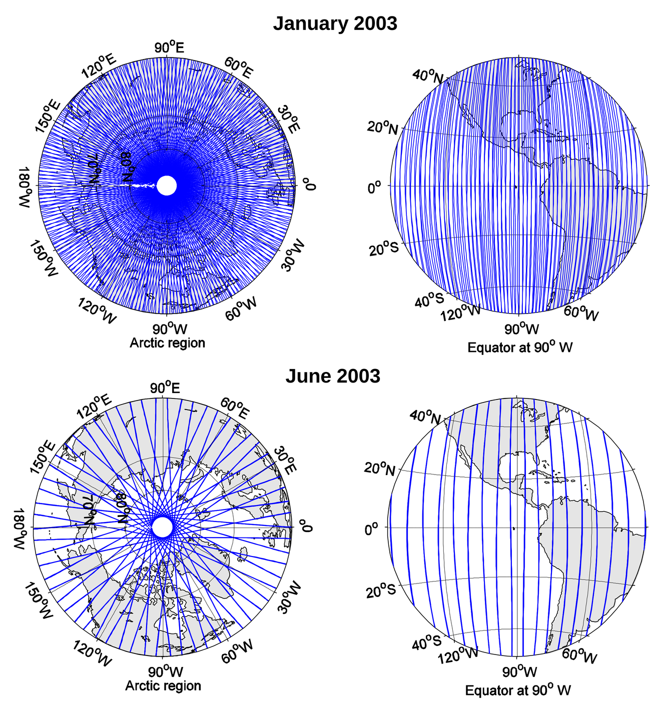
The energy integral approach connects position, velocity and accelerometry to the disturbing potential:

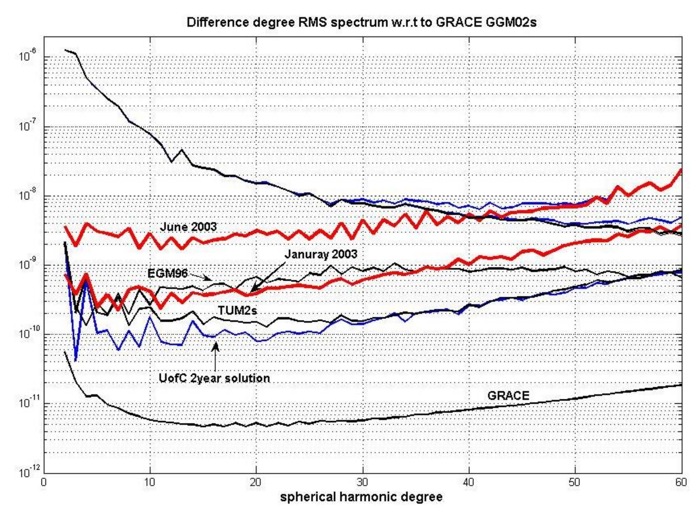
$$T + c = E_{kin} - U - Z - \int \left(f + \sum_k g_k \right) dx$$

$$\begin{aligned}
T &= \text{disturbing potential} \\
c &= \text{integration constant} \\
E_{kin} &= \text{kinetic energy} \\
U &= \text{normal gravitational potential} \\
Z &= \text{centrifugal potential} \\
\int f dx &= \text{dissipative energy} \\
\int \sum_k g_k dx &= \text{time variable changes}
\end{aligned}$$

Motivation for local geoid determination in high-latitude areas

- Groundtrack changes constantly since satellite is slowly decaying
  - →top figure shows example of good ground coverage in January 2003
  - →middle figure shows poor ground coverage in June 2003
- Global gravity field solution is influenced by groundtrack pattern since a global spherical harmonic analysis is limited by the equatorial data spacing.
  - →Bottom figure shows degree RMS spectra of the difference between a monthly CHAMP solution and GGM02s and reveals the impact on the accuracy of the monthly solution due to the groundtrack
- Due to a near polar orbit the data density is higher in polar areas and a local gravity field determination can make use of the full potential of the measurements in these areas.



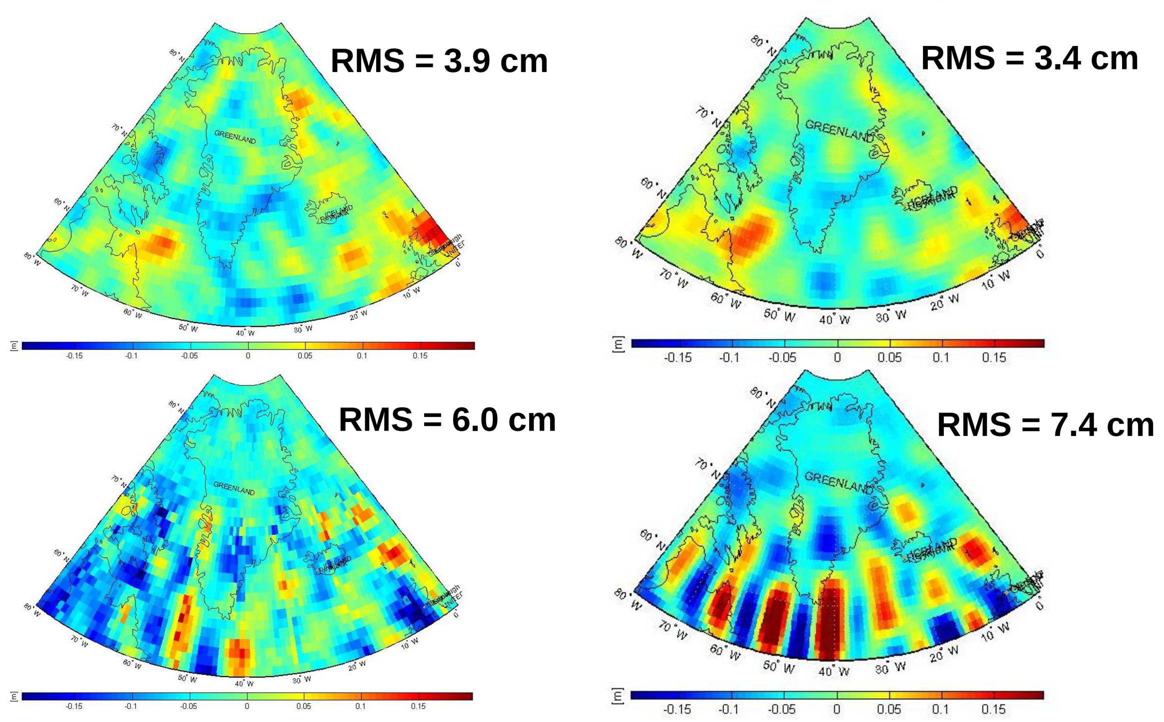


Least-squares prediction at satellite height

- Vertical interpolation to mean orbit radius
- Basic formula for least-squares prediction: $\bar{s} = C_{sl} C_{ll}^{-1} l$
- Covariance model for C_{sl} and C_{ll}: Tscherning-Rapp

Comparison of geoid heights: monthly CHAMP solution vs. GGM02s

	Local LS-prediction	Global SH-analysis
January 2003	RMS = 3.9 cm	RMS = 3.4 cm
June 2003	RMS = 6.0 cm	RMS = 7.4 cm



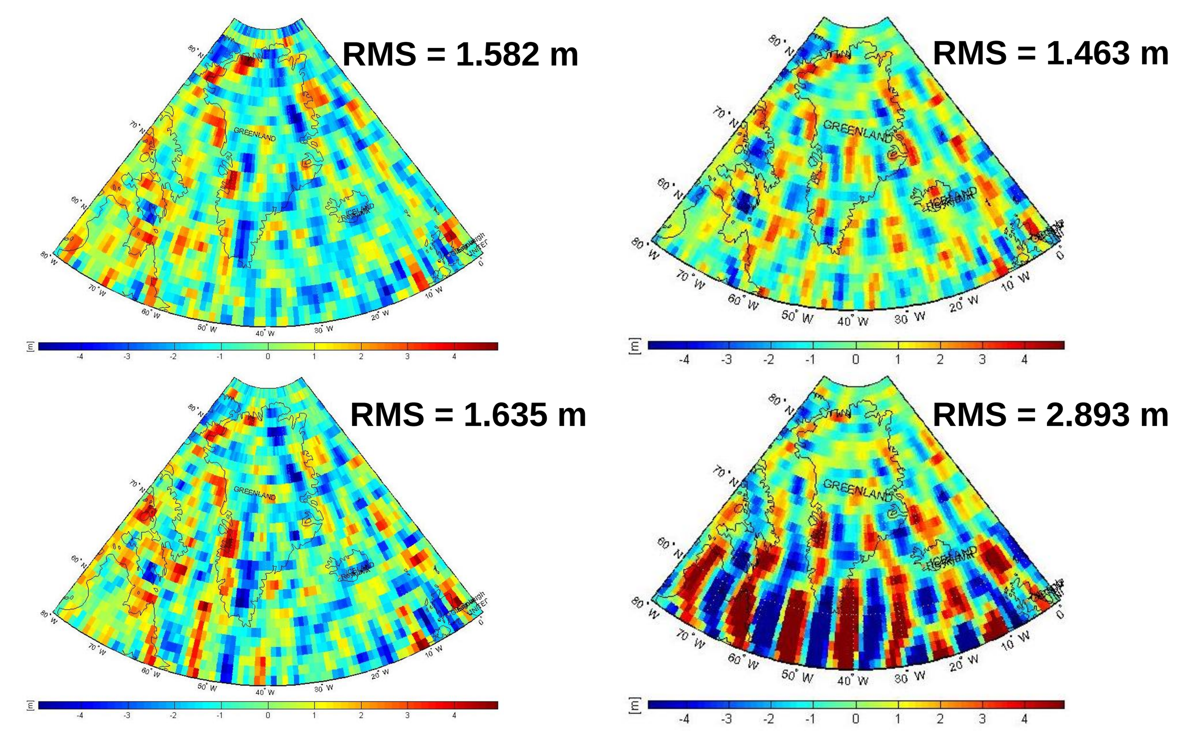
- Errors are at the cm-level and less pronounced than in a global solution, i.e., LS-prediction is an excellent tool for gridding, e.g., as initial step for a spherical harmonic analysis by FFT

Least-squares collocation

- LS-prediction + downward continuation → Least-squares collocation
- Regularization due to ill-conditioning of the covariance matrix of the observations necessary

Comparison of geoid heights: monthly CHAMP solution vs. GGM02s

	Local LS-collocation	Global SH-analysis
January 2003	RMS = 1.582 m	RMS = 1.463 m
June 2003	RMS = 1.635 m	RMS = 2.893 m



- Groundtrack effect is considerably smaller in local solution
- Downward continuation causes loss of accuracy
- Regularization enables solution but is strongly dependent on the regularization parameter

Conclusion

- Least-squares collocation yields consistent local monthly solutions which are nearly independent of the groundtrack pattern
- Monthly solutions with good ground coverage are on the same level as the global solution, but local LS-collocation for high-latitude areas clearly yields an improvement for a monthly solution with a poor ground coverage
- Results at satellite height are at the cm-level. LS-prediction is an excellent tool for gridding

Future work

- Improvement in the data selection in order to stabilize the covariance matrix of the observations
- Investigation of the dependence on the regularization parameter
- Testing of covariance functions from global geopotential models
- Derivation of local covariance functions
- Transfer procedure to other areas, e.g., Canada, Antarctica, …

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