CHAMP Gravity Results using the Energy Balance Approach with Emphasis on Algorithmic Aspects

UNIVERSITY OF CALGARY

GEOMATICS ENGINEERING

Abstract:

The poster stresses two main aspects of the processing of CHAMP GPS- and accelerometer data.

1. Kinematically derived orbit determination yields position only. Velocities have to be derived numerically.
2. In the further processing accelerometer data is used to correct for dissipative forces. The necessary calibration is done using crossover points.

Preliminary results are on the dm-level.

Introduction:

- Feasibility of the energy integral approach is proven.
- The basic characteristic is the use of GPS derived position and velocity data and the correction for non-gravitational forces derived from accelerometer data.
- Purely kinematic CHAMP orbits avoid the contamination with a priori gravity field information but velocities have to be derived numerically.
- In the data processing a calibration of the accelerometer data is necessary to account for the bias and scale of the accelerometer.

Method:

The energy integral approach connects the position, velocity and accelerometer to the disturbing potential.

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

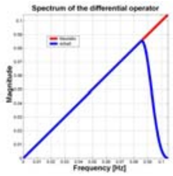
T	=	disturbing potential
c	=	integration constant
E_{kin}	=	kinetic energy
U	=	normal gravitational potential
Z	=	centrifugal potential
$\int f dx$	=	dissipative energy
$\int \sum_k g_k dx$	=	time variable changes

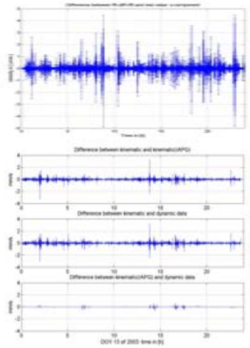
Velocity Determination:

- Numerical differentiation in the spectral domain using the ideal differentiator
- Low-pass filtering enables data smoothing
- Edge effects cause large errors → loss of data
- Required accuracy: RMS = $10^{-4} \frac{m}{s}$

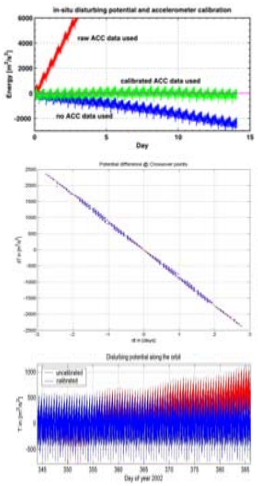
- Test results with simulated data from ITG, Bonn:
  - Simulated noiseless orbits from EGM96 gravity model up to degree 300
  - Comparison of differentiated positions with simulated velocity
  - RMS = $10^{-7} \frac{m}{s}$

- Test results with kinematic and dynamic data from IAPG, Munich
  - RMS = $10^{-4} \frac{m}{s}$
  - Kinematic velocities of IAPG are known to be smoothed too strong





Crossover Calibration:

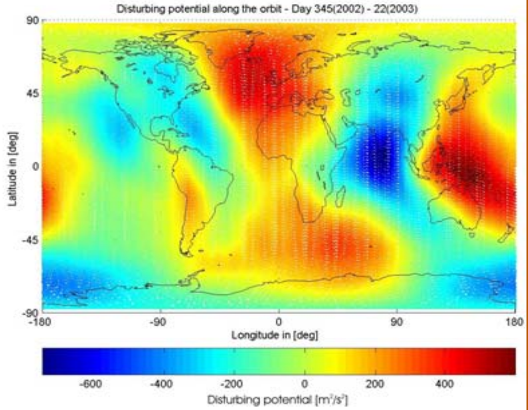


- Ignoring dissipative forces the disturbing potential drifts away from a constant level (blue curve), i. e. energy dissipation takes place.
- Correcting for the dissipation with raw accelerometer data yields a worse drift (red curve) due to the scale and bias of the accelerometer.
- Crossover adjustment is used for calibration.

Procedure:

1. Daily correction for scale and bias
   1. Search for crossover location
   2. Creation of pseudo-measurement for disturbing potential differences by interpolation and vertical continuation
   3. Linear Regression
2. Connection of the daily solution
   1. Search for crossover location
   2. Least square adjustment

Preliminary Results:



Conclusion:

- Velocity determination is promising but problems with edge effects cause large errors
- Filter technique enables smoothing of data
- Results with simulated data reach $\mu m/s$ - level
- Results with actual data indicate $0.1 mm/s$ - level

- Crossover calibration necessary for drift correction
- Linear Regression as adjustment model for bias and drift correction
- Extension of the adjustment model for the determination of the scale of the accelerometer necessary.
- Connection of daily solutions using crossover points
- Time consuming crossover search

- Preliminary results are on the dm-level.

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Researchers: **Matthias Weigelt, mlbweige@ucalgary.ca**
Nico Sneeuw

Geomatics Engineering, University of Ca
2500 University Drive
Calgary, AB, Ca