M. Weigelt, A. Jäggi, L. Prange, W. Keller, N. Sneeuw

TOWARDS THE TIME-VARIABLE GRAVITY FIELD FROM CHAMP
Questions

• Did we get everything out of the CHAMP data?
• Is the time variable gravity field really out of reach?
• What do we learn for future satellite missions?
Previous studies & limitations

- based on the energy balance approach
- two years of GPS-data with 30 s sampling
- no dealiasing products
- no covariance information
Processing refinements
Refinements

Acceleration approach:

$$\nabla V = \ddot{x} - f_{3rd\text{Body}} - f_{\text{Tides}} - f_{\text{Rel}} - f_{\text{Grav}}$$

- three times the number of observations
- three dimensional observations

Improved GPS positioning:

- 10 s sampling
- estimated absolute antenna phase center model
- new IGS standards
- …

Prange 2010
Outliers vs. poor observations

- Typically threshold based outlier detection based on residuals:
Outliers vs. poor observations

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- Localizing outlier detection necessary
Outliers vs. poor observations

• Typically threshold based outlier detection based on residuals:

• Localizing outlier detection necessary

• Consider (synthetical) covariance information
Results using outlier detection

![Graph showing results with and without outlier detection]

- Without outlier detection
- With outlier detection

January 2003
CHAMP vs. GRACE monthly solutions

degree RMS

ITG-GRACE 2010s

Previous studies CHAMP

CHAMP

GRACE - GFZ RI. 4
Monthly solutions
Pushing the limits – combination strategies

Standard case: single month solution
Pushing the limits – combination strategies

Standard case: single month solution

Combining n-month with unit weight
Pushing the limits – combination strategies

Standard case: single month solution

Combining n-month with unit weight

Combining n-month with Bartlett weight
Pushing the limits – combination strategies

Standard case: single month solution
+ Grace A and Grace B

Combining n-month with unit weight
+ Grace A and Grace B

Combining n-month with Bartlett weight
+ Grace A and Grace B
Comparison of combination strategies

![Graph showing comparison of CHAMP and GRACE - GFZ RI.4 degree RMS values over degrees from 0 to 90, with March 2003 indicated.]
Comparison of combination strategies

- CHAMP: 3 month – unit
- GRACE – GFZ RI.4

March 2003
Comparison of combination strategies

March 2003
CHAMP-only solution with Bartlett option
Adding GRACE …

CHAMP
CHAMP: 3 month – Bartlett

GRACE – GFZ RL.4

March 2003
Adding GRACE …

March 2003
Adding GRACE ...
Adding GRACE …
Adding GRACE …

- CHAMP
- CHAMP+GRACE A/B
  3 month – Bartlett

March 2003

GRACE – GFZ Rl.4

degree RMS

10^{-11}

10^{-10}

degree l

5 10 15 20 25
Results for CHAMP + GRACE
Time series of coefficients

\[ C_{44} \]

\[ C_{40} \]

Correlation

Universität Stuttgart

- Red: GRACE – GFZ RL. 4
- Black: CHAMP + GRACE
Time series of coefficients

\( C_{44} \)

\[ \rho = 0.79 \]

\( x 10^{-10} \)

\( \times 10^{-10} \)

2003 2004 2005 2006 2007 2008 2009

time

\( C_{40} \)

\[ \rho = -0.08 \]

\( x 10^{-10} \)

\( \times 10^{-10} \)

2003 2004 2005 2006 2007 2008 2009

time

Correlation

Single coefficients comparison capability
Spatial pattern

October 2003:

February 2004:
Conclusion

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• What do we learn for future satellite missions?
Conclusion

• Did we get everything out of the data of CHAMP? **CHAMP still offers a wealth of information**

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Conclusion

- Did we get everything out of the data of CHAMP?
  CHAMP still offers a wealth of information
- Is the time variable gravity field really out of reach?
  No, but processing needs further improvements
- What do we learn for future satellite missions?
Conclusion

• Did we get everything out of the data of CHAMP?  
  **CHAMP still offers a wealth of information**

• Is the time variable gravity field really out of reach?  
  **No, but processing needs further improvements**

• What do we learn for future satellite missions?  
  **“Real” covariance information needed**
Conclusion

• Did we get everything out of the data of CHAMP?
  CHAMP still offers a wealth of information

• Is the time variable gravity field really out of reach?
  No, but processing needs further improvements

• What do we learn for future satellite missions?
  “Real” covariance information needed
  Increase the number of observations
THANK YOU

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Appendix
Time variable signal?

GRACE – GFZ RI. 4
CHAMP + GRACE