On the combination of gravity field time series derived from kinematic positions of Low Earth Orbiting satellites

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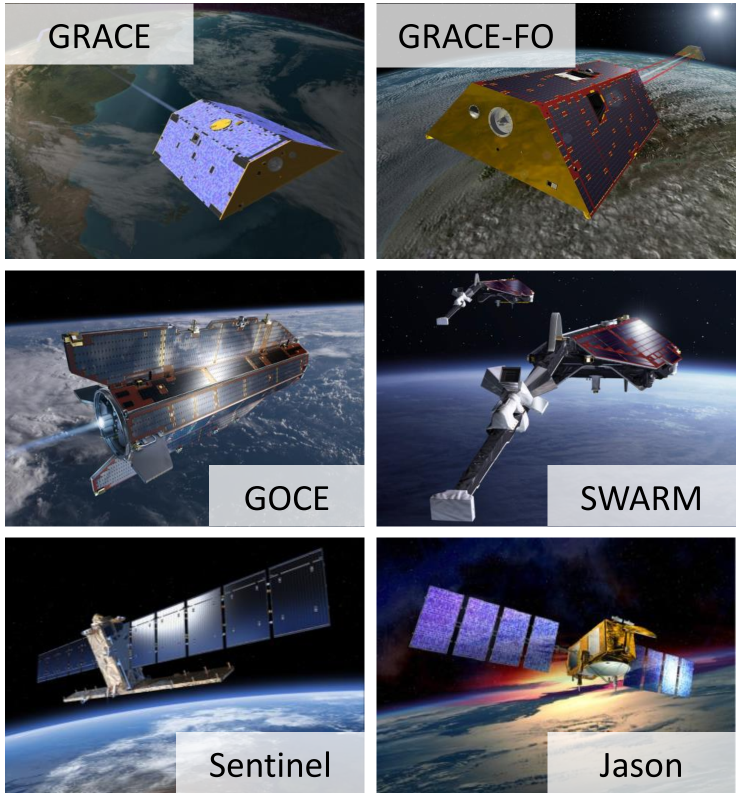
Introduction

- **Motivation**
  - Any Low Earth Orbiting (LEO) satellite with a GPS receiver may serve as a gravity field sensor (in addition to dedicated missions)
  - Kinematic LEO positions are used for gravity field recovery in a generalized orbit determination problem

- **Our goal:** Multi-LEO gravity field time series taking advantage of
  - Large number of observations
  - Complementary orbital configurations

- **Focus here:** Combination of monthly LEO gravity field time series



Source: ESA, NASA

Overview of LEO gravity field time series

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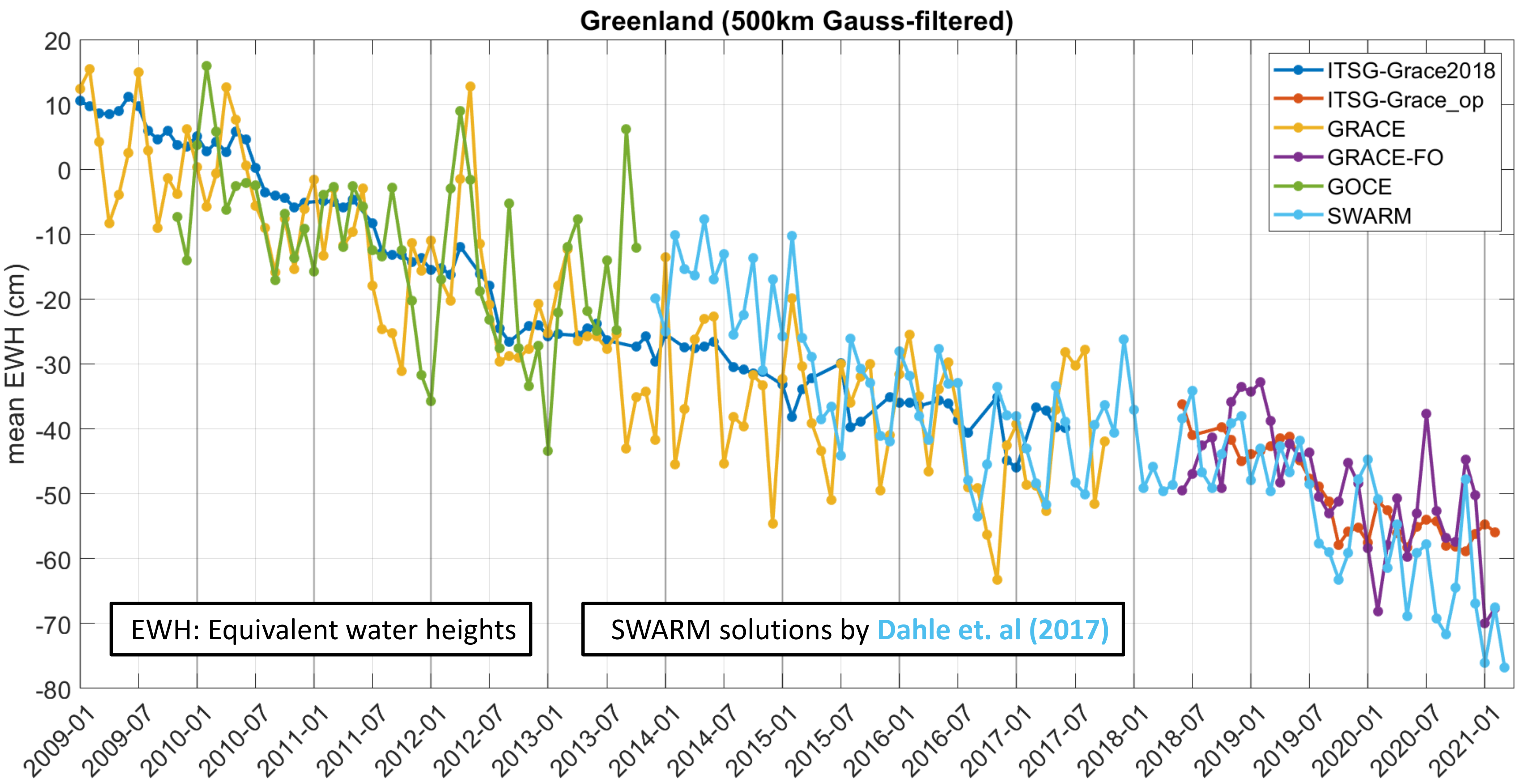
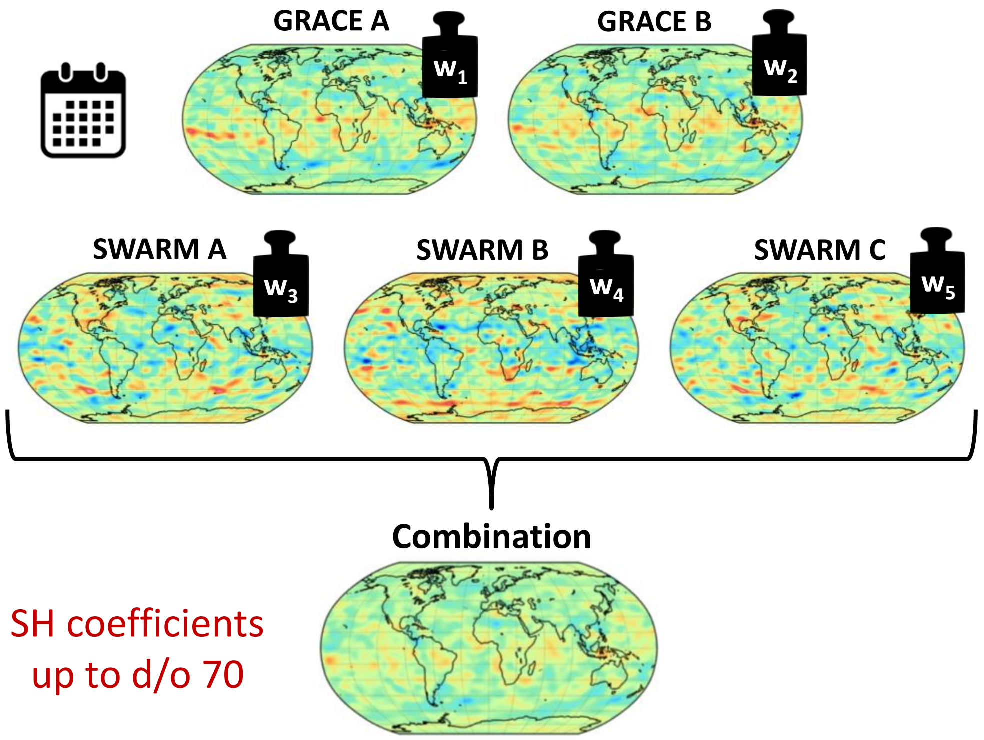


Combination of monthly gravity field time series

- Combination strategy on solution level
  - Combination of individual satellite solutions
  - Monthly field-wise weights



- Variance component estimation (VCE)
  - SH coefficients are used as pseudo-observations
  - Field-wise weights (Jean et. al, 2018):

$$w_{i,k} = \left(1 - \frac{w_{i,k-1}}{\sum_i w_{i,k-1}}\right) \frac{1}{\mathrm{RMS}(\boldsymbol{x}_i - \hat{\boldsymbol{x}}_{k-1})^2}$$

$$w_{i,0} = 1/n_{\mathrm{sol}}$$

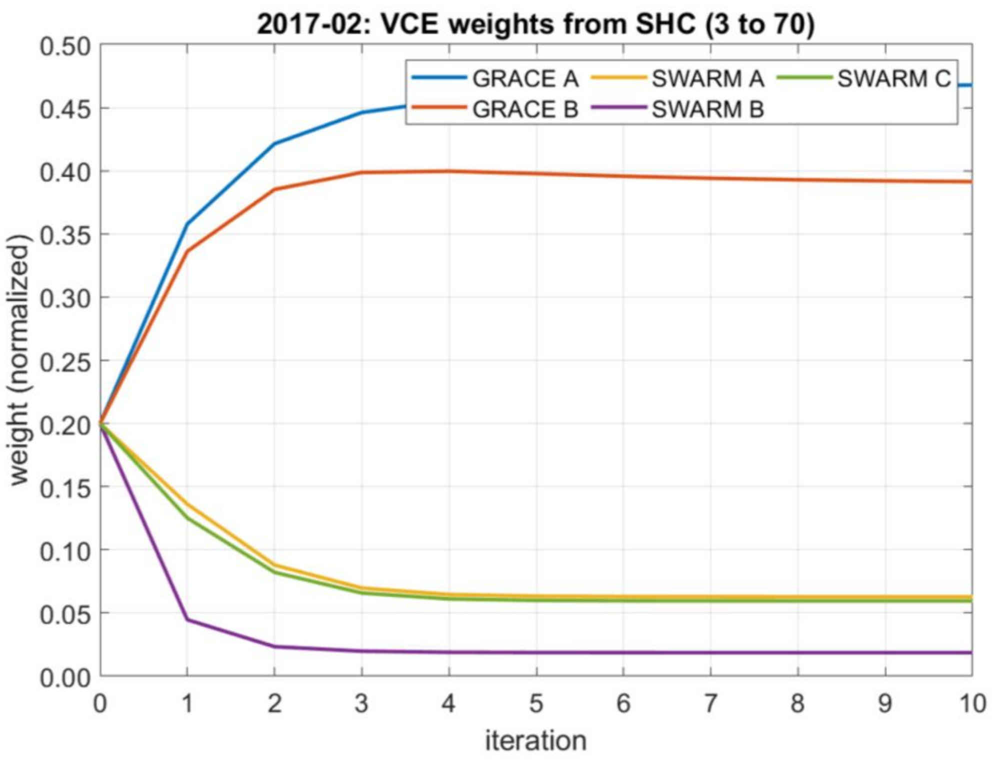
  - Combination in iteration step k:

$$\hat{\boldsymbol{x}}_k = \frac{1}{\sum_i w_{i,k}} \sum_i w_{i,k} \boldsymbol{x}_i$$

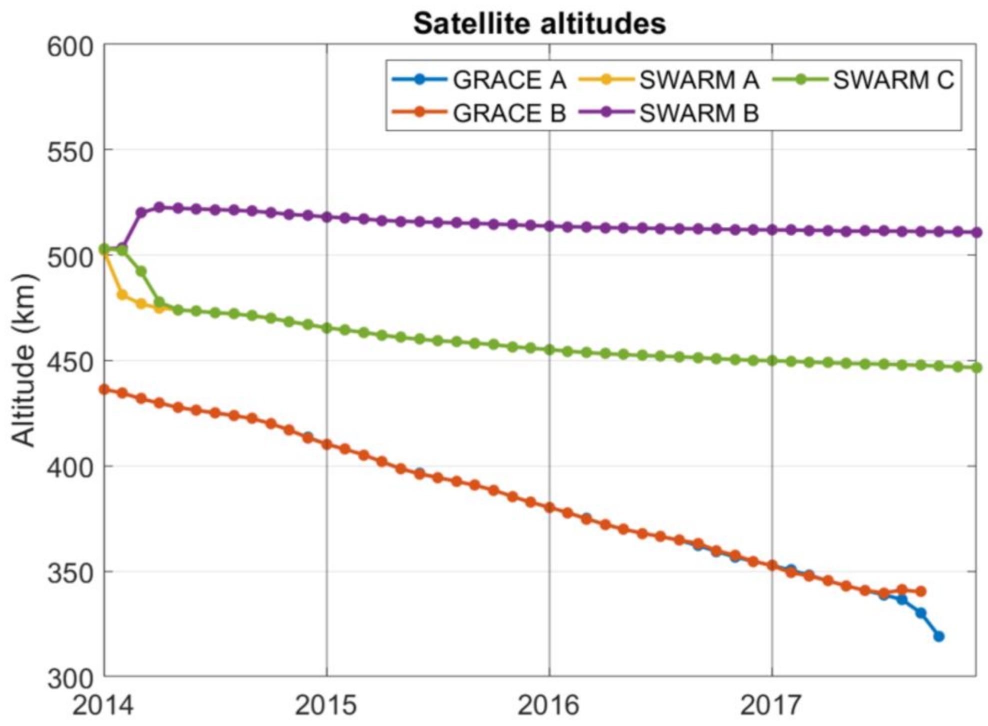
SH coefficients of solution i

Variance component estimation: GRACE/SWARM

- Weights based on unfiltered SHC



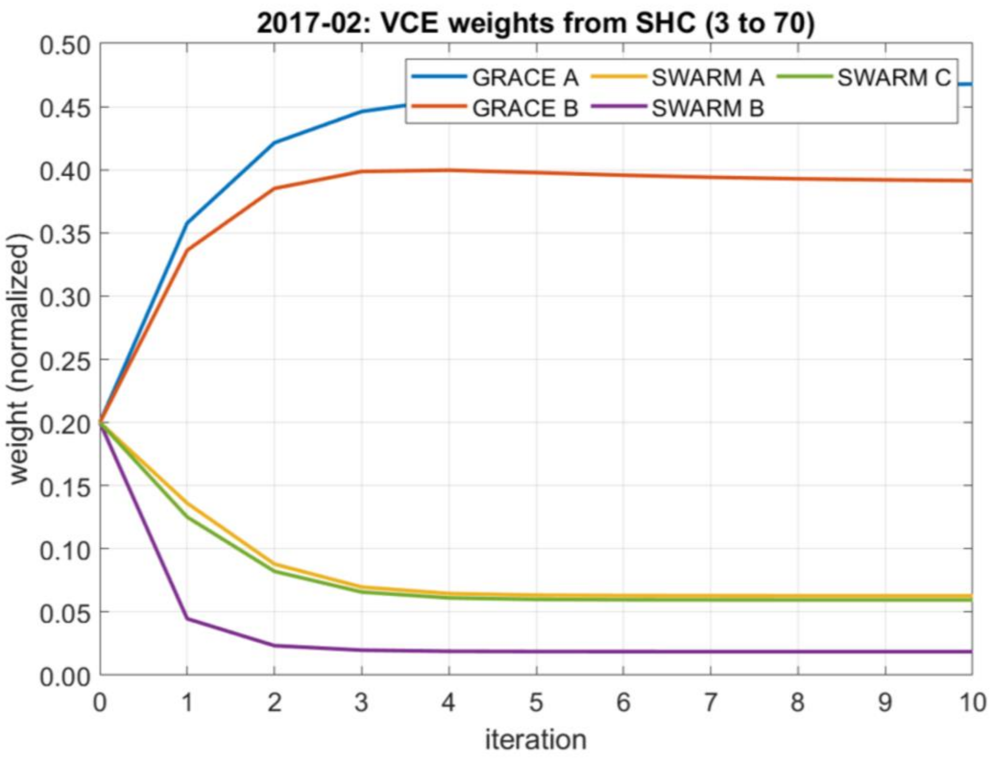
- Satellite altitudes



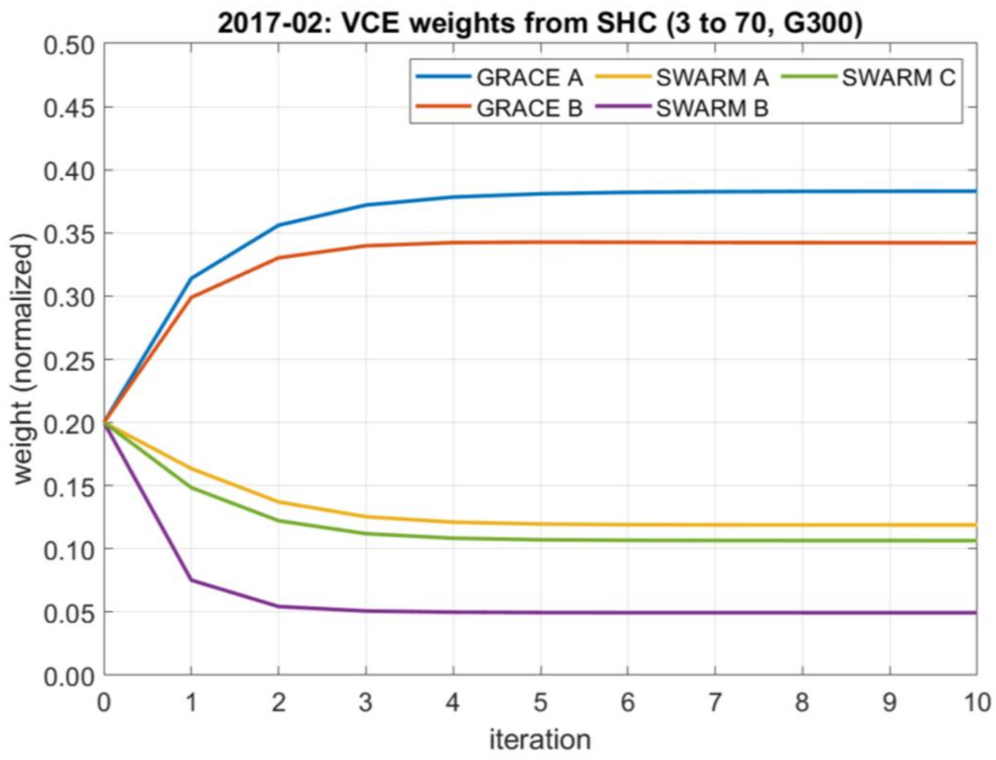
➢ Weights are dominated by the noise of the high-degree coefficients

Variance component estimation: GRACE/SWARM

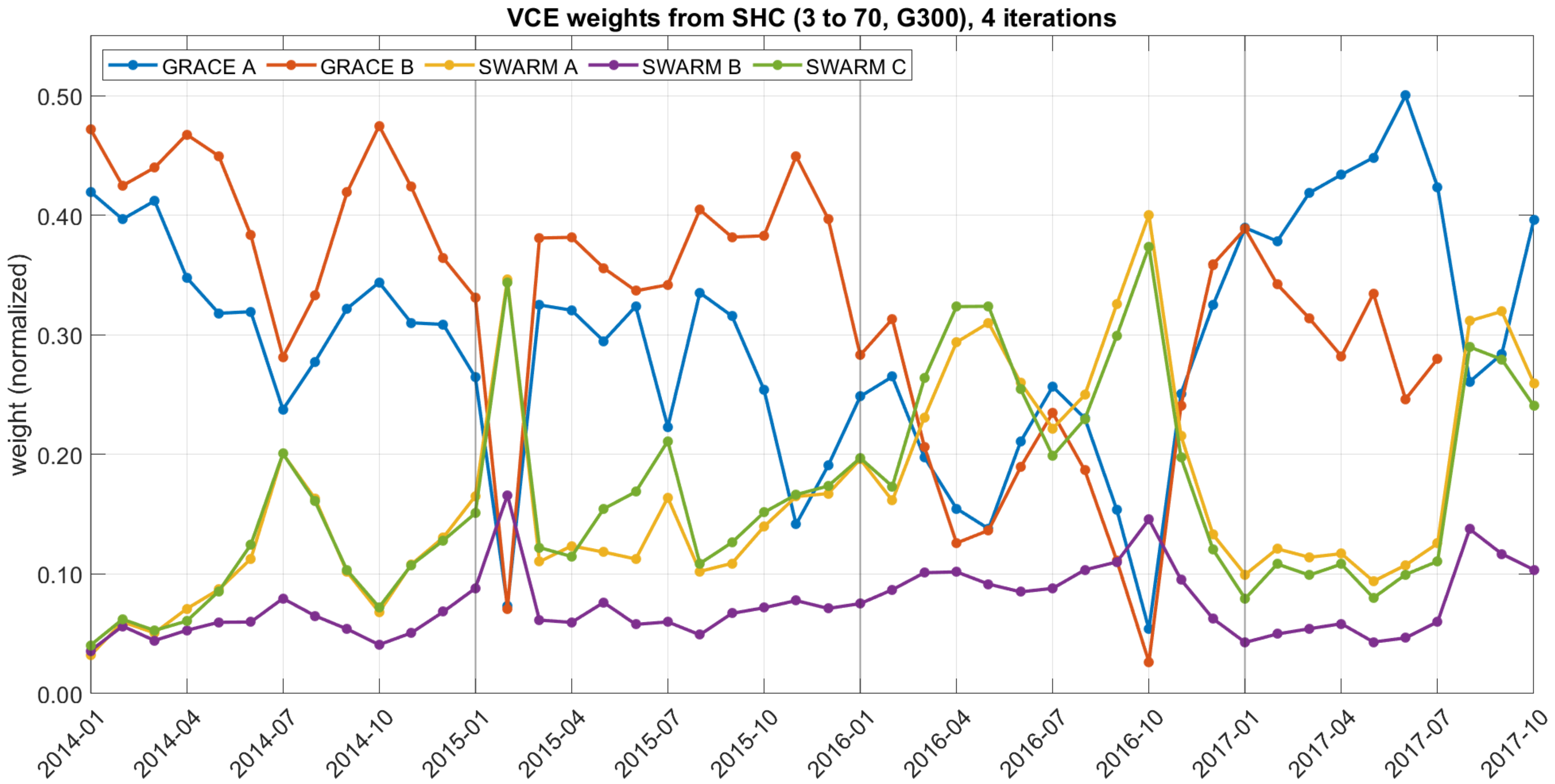
- Weights based on unfiltered SHC



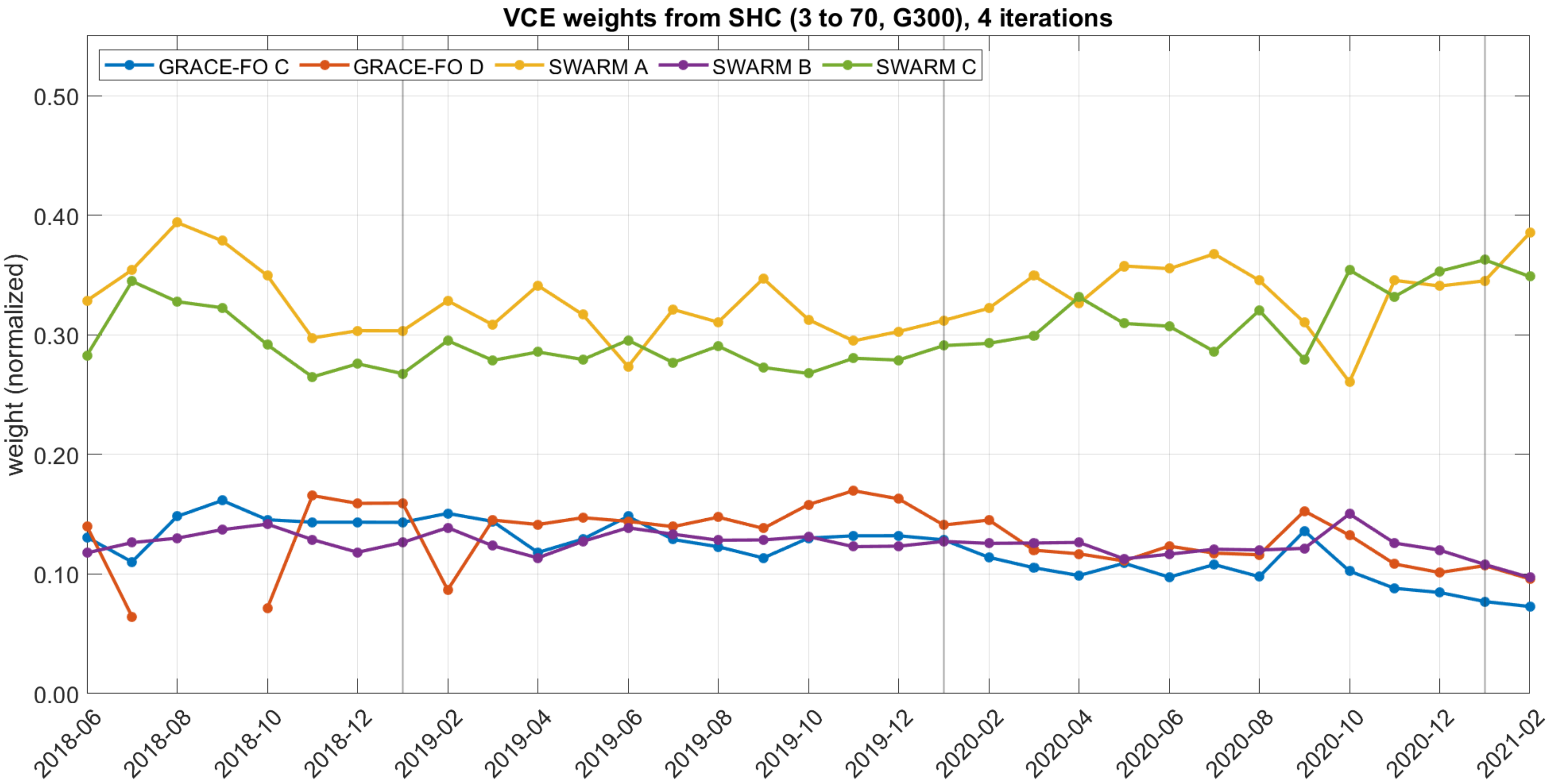
- Weights based on filtered SHC (**here:** 300km Gauss)



Variance component estimation: GRACE/SWARM



Variance component estimation: GRACE-FO/SWARM



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Evaluation of mass trends and changes

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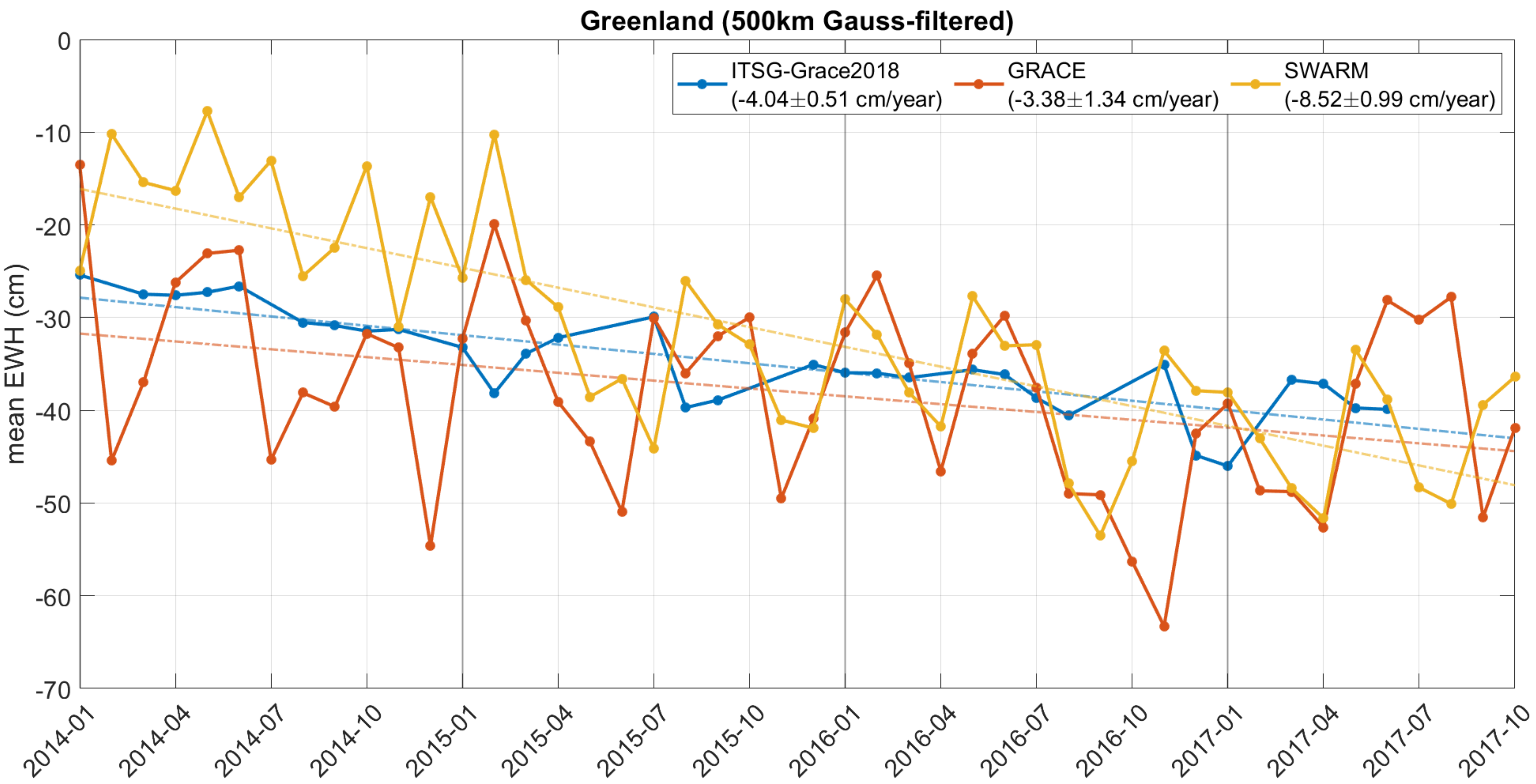
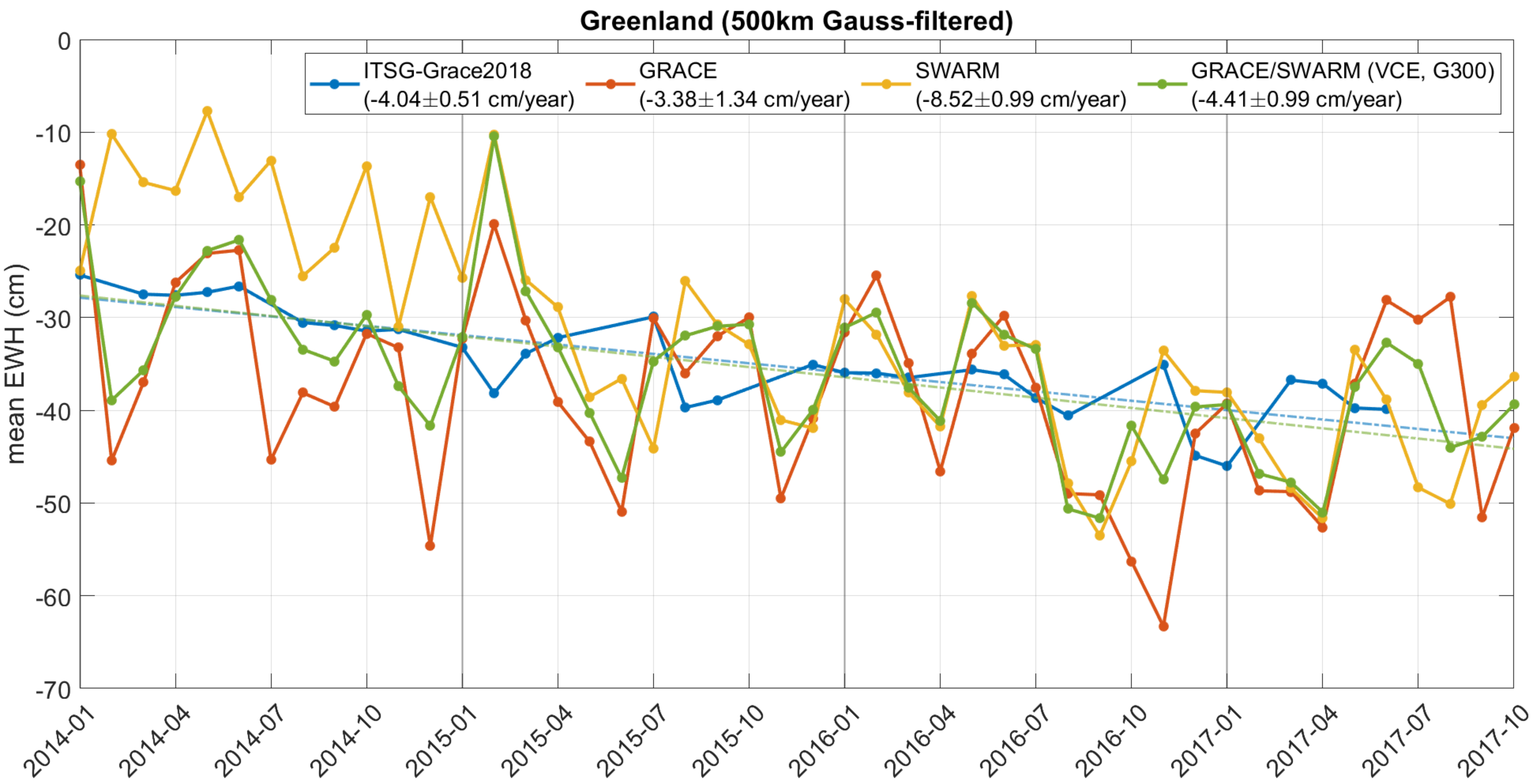


Evaluation of mass trends and changes



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Summary and Outlook

- Time-variable gravity field recovery from kinematic LEO positions
- Combination of monthly LEO gravity field time series on solution level

- Combination of GRACE/-FO and SWARM time series
  - Field-wise weights derived from variance component estimation
  - Filtering helps to reduce the impact of high-degree coefficients on the VCE weights
  - Combined time series provide an improved estimation of mass trends and changes

- Next steps
  - VCE settings still need to be optimized → choice of applied filter, iteration
  - Combination of LEO gravity field time series on normal equation level
  - Extension of GRACE/-FO time series + inclusion of new LEO satellites

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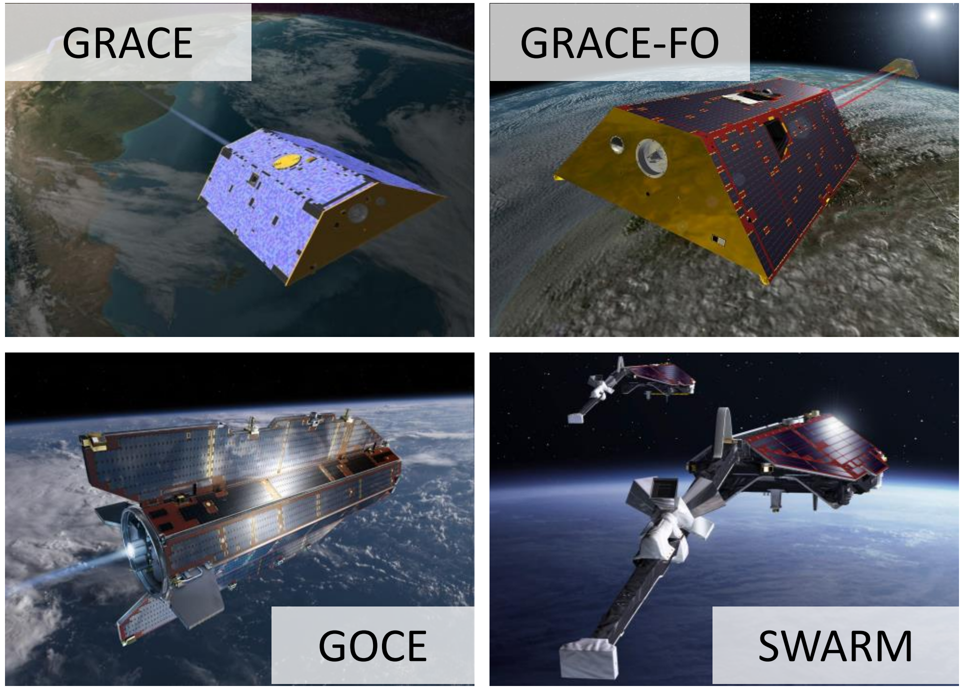
Thank you for your attention



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References

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Jean Y, Meyer U, Jäggi A (2018): Combination of GRACE monthly gravity field solutions from different processing strategies. Journal of Geodesy 92:1313–1328, DOI: 10.1007/s00190-018-1123-5