Combination of Swarm gravity field models on normal equation level

ESA/DISC project "Multi-approach gravity field models from Swarm GPS data"

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Outline

1. Multi-approach gravity field models from Swarm GPS data
2. Combination strategy
3. Combination at normal equation level
4. Conclusion

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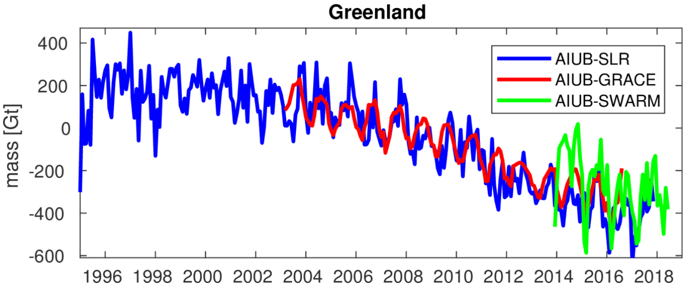
Example application: Mass loss in Greenland



- GRACE-derived mass variations serve as reference
- All gravity fields truncated at degree 6 (max. resolution of SLR), no extra filter applied
- Swarm results: more noisy and larger signal amplitude (unknown reason)

Combination strategy

Same kinematic orbits, different ACs

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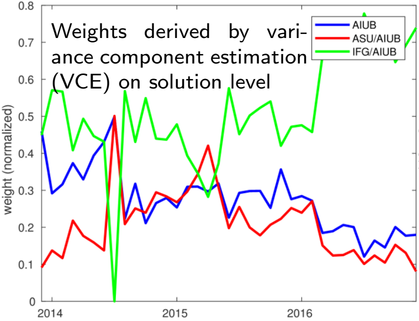
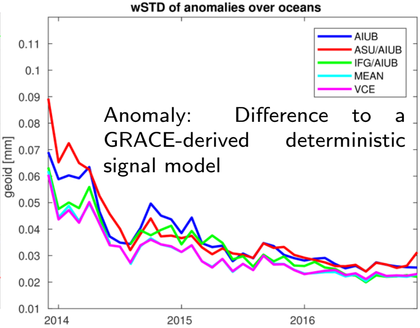
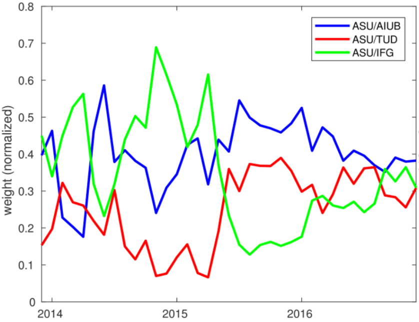


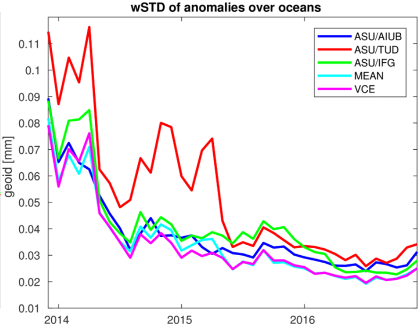


- The combination (on solution level) based on AIUB kin. orbits shows advantages for the IfG processing strategy

Same AC, different kinematic orbits

Example: ASU gravity fields based on different kinematic orbits





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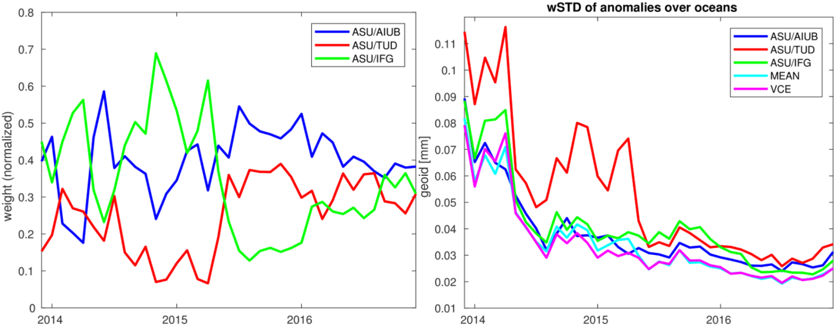

- Advantages for IfG orbits during periods of high solar activity, for AIUB orbits during periods of reduced solar activity or improved tracking
- TUD orbits suffer from artifacts due to ionospheric disturbances during times of high solar activity

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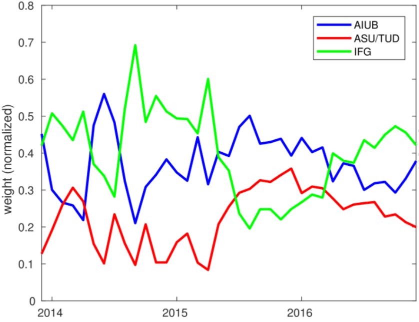
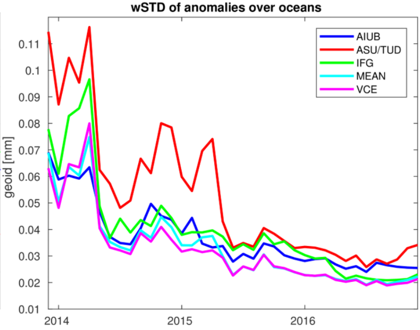
- If certain orbits show pronounced problems, the AC processing these orbits will get lower weights (unattractive)

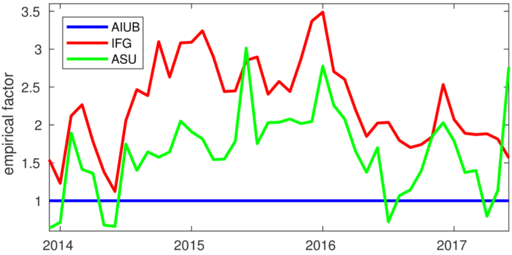




Combination at normal equation (NEQ) level

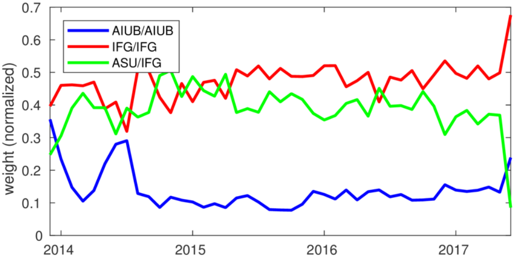
Relative weighting/scaling of NEQs (1)

- Different ACs use different normalizations for NEQ generation $\longrightarrow$ NEQs first need to be scaled to balance the general level of impact on the monthly combination (pair-wise comparison of solutions)
- Only apply one scaling factor per time series to keep relative accuracy information between months



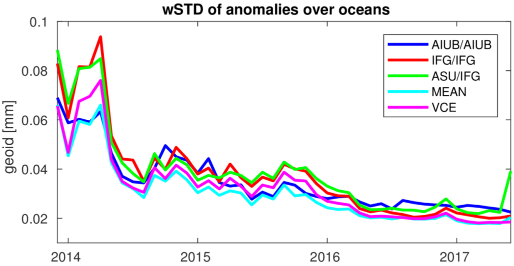
Relative weighting/scaling of NEQs (2)

Weights derived from VCE (on solution level):



- Weights are biased, since kinematic orbits are used unevenly ($2\times$IfG, $1\times$AIUB) $\longrightarrow$ AIUB solution systematically differs from other solutions and gets downweighted
- Not applied for final combined solutions

Validation: noise over ocean areas



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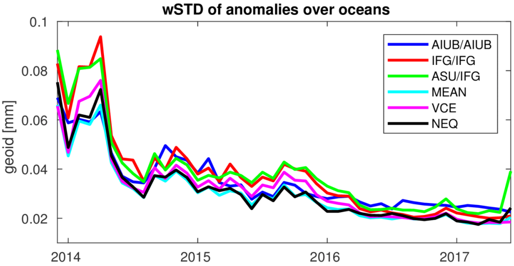

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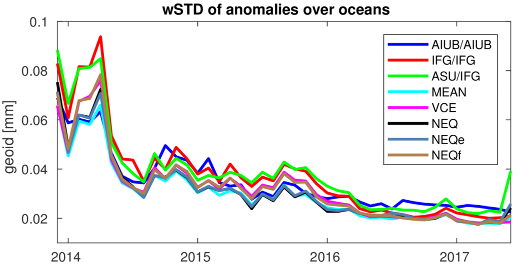
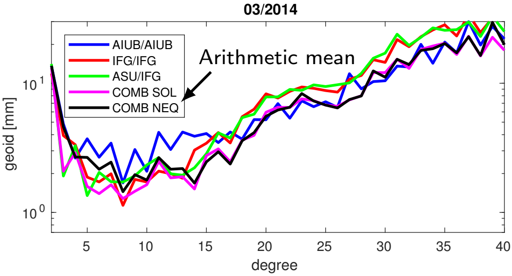


- Combination on solution level: VCE is not optimal (orbit bias) and is out-performed by the arithmetic mean
- The arithmetic mean at NEQ level closely resembles the arithmetic mean at solution level
- Applying VCE-based weights at NEQ-level (NEQf) closely reproduces the combination by VCE at solution level.
- Introduction of monthly empirical scaling factors (NEQe) will not result in significant improvement

Spectral analysis of anomalies



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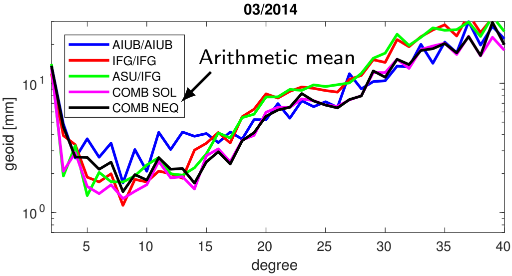

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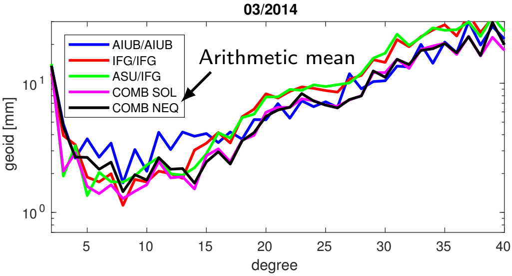

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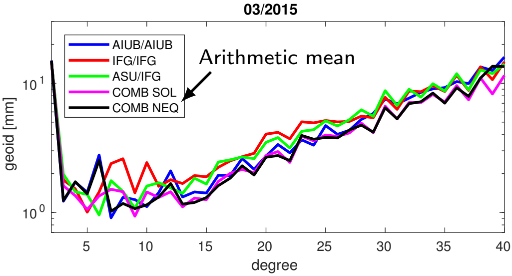

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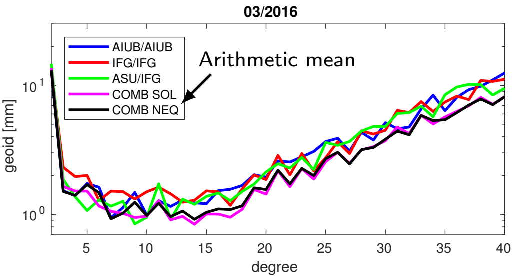

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Conclusions

- Swarm kinematic orbits from different processing centers show different performances, depending on ionospheric activity
- An unbiased combination of Swarm-derived gravity fields from different ACs requires a homogeneous use of kinematic orbits, otherwise VCE will downweight solutions which are derived from underrepresented kinematic orbits
- At low degrees combination on NEQ level is dominated by AIUB solution due to its (too) low formal errors. This is problematic during high ionospheric activity, where the AIUB solutions are degraded in the lower degrees

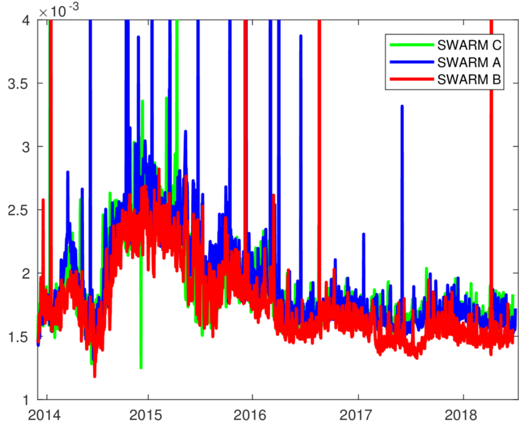
→ Tests with revised strategies to mitigate ionosphere-induced artifacts in AIUB orbits on-going (however, seems to improve mainly higher degrees)

Thank you

Swarm gravity field processing at AIUB

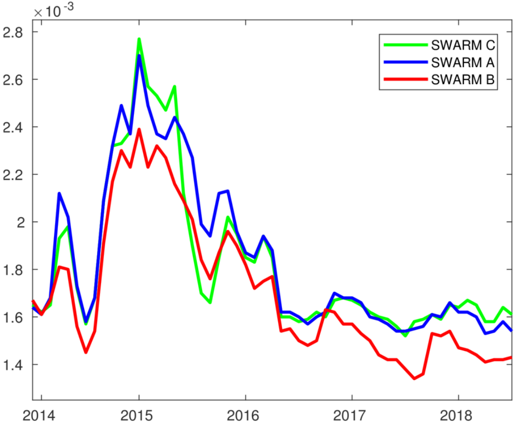
Quality control (1)

Daily RMS of orbit fit reflects ionospheric disturbances due to solar activity:



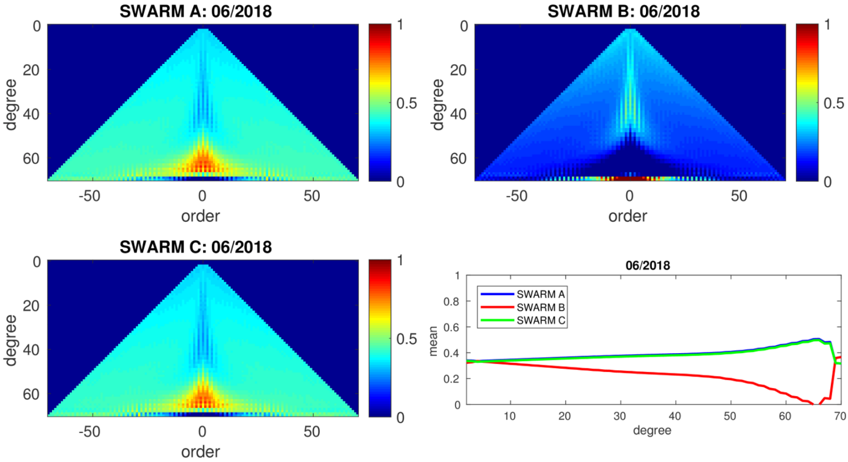
Quality control (2)

So does the monthly RMS of gravity field model adjustment:



Contribution analysis

Contribution of individual Swarm satellites to monthly gravity field solutions:



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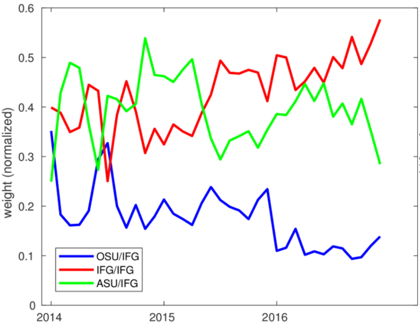
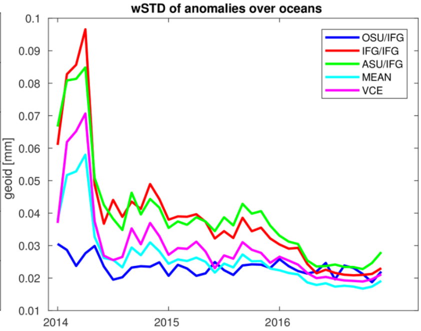
Quality checks of individual contributions (1)





- Combination by Variance Component Estimation (VCE) on solution level (convergence after 3-4 iterations)
- Noise is evaluated independently by variability over ocean areas
- Low weights together with low noise indicate damaged signal

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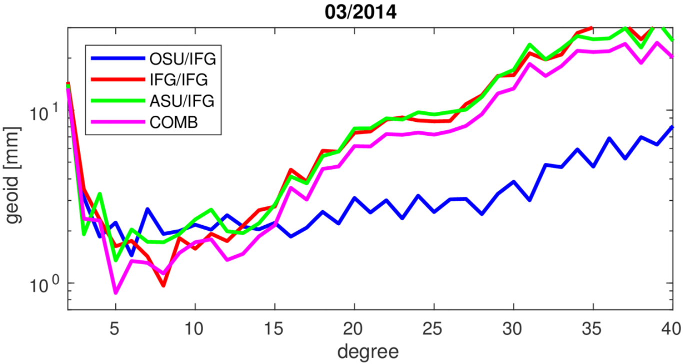

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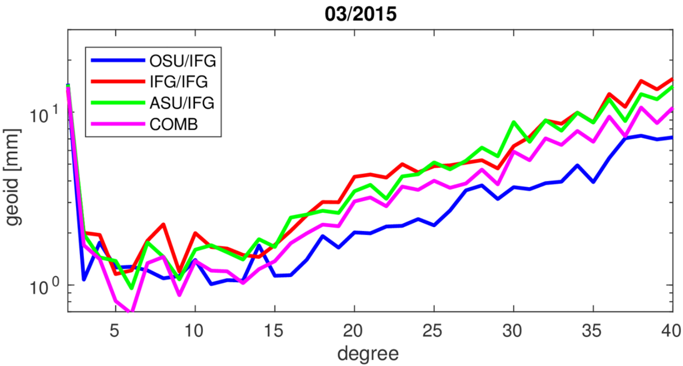

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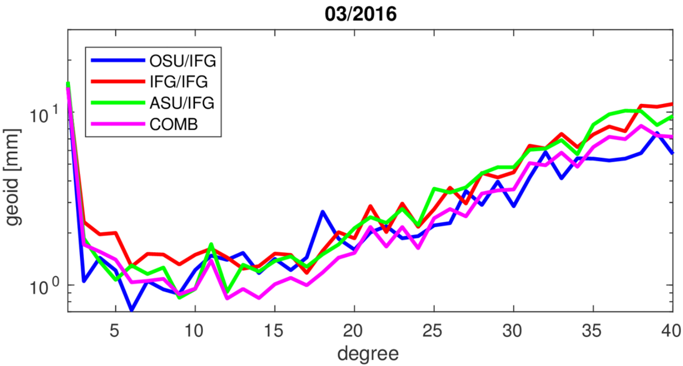

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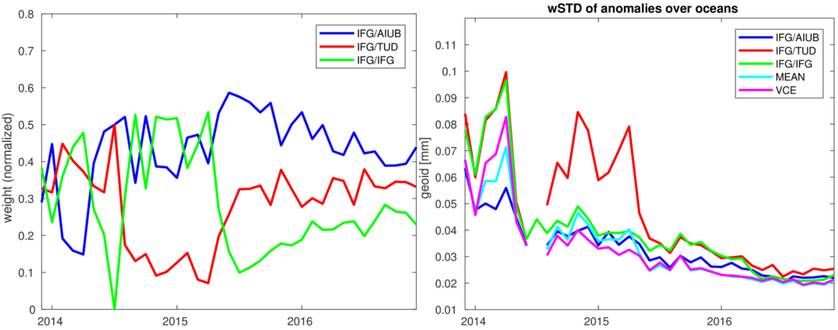

- Combination of IfG gravity fields based on different kinematic orbits confirms the findings of the ASU combination