Signals of Geophysical Nature in GRACE and GRACE-FO Post-Fit Range-Rate Residuals

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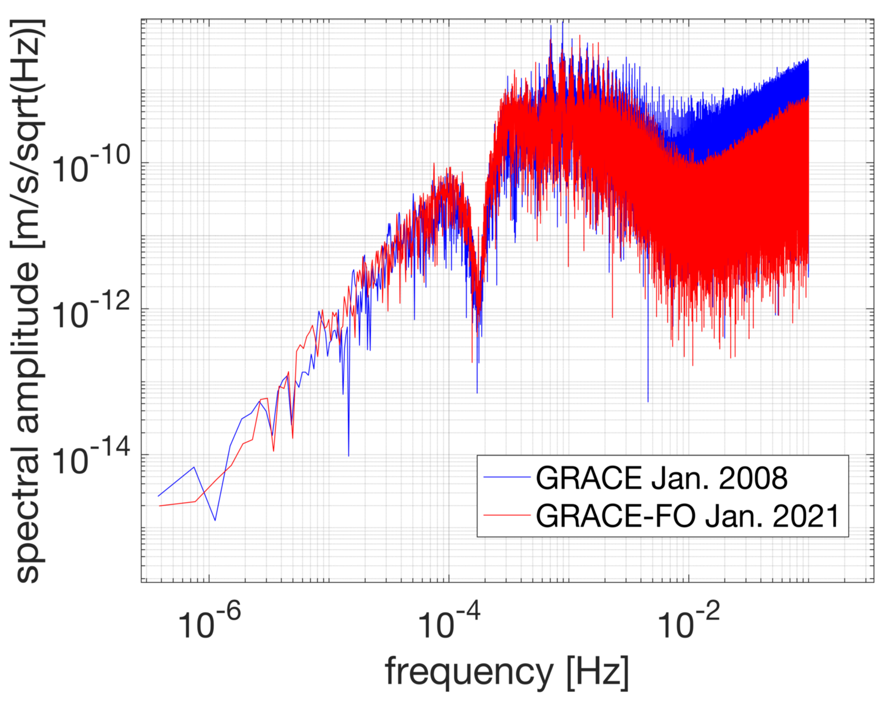
1. Abstract

- Post-fit residuals of satellite-to-satellite tracking measurements of the GRACE and GRACE-FO missions obtained after a common estimation of orbit and gravity field parameters should ideally contain measurement noise with a behavior that meets expectations for the involved sensors. In reality, obtained GRACE and GRACE-FO post-fit range-rate residuals represent a complex superposition of different effects, e.g. of instrumental, environmental and geophysical nature. In this contribution, we focus on the geophysical signals in the post-fit residuals of the LUH GRACE and GRACE-FO time series. We apply band-pass filtering to extract the geophysical signal buried in the residuals and analyze the most distinctive signatures for their spatial and temporal behavior.

2. Data

- In this contribution we analyze GRACE and GRACE-FO K-band range-rate post-fit residuals covering the time span 2003-2022. The residuals are obtained as part of the recovery proccess of monthly solutions **[1]**. For orbit propagation (state-of-the-art) models were used, among them FES2014b **[2]** (ocean tides) and AOD1B-RL06 **[3]** (non-tidal atmosphere and ocean, atmosheric tides).

3. Exemplary Residuals (Jan. 2008/2021)



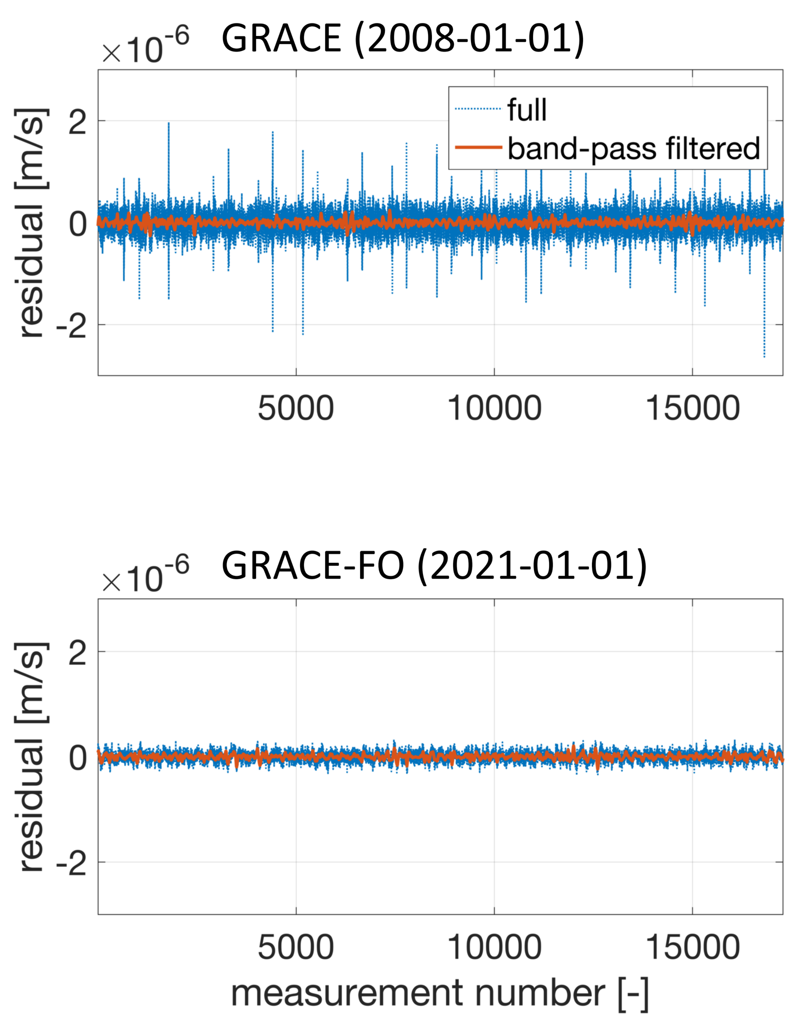


Fig. 1: (**left**) Power spectral density of exemplary GRACE and GRACE-FO residuals.

Fig. 2: (**right**) Time series of GRACE and GRACE-FO residuals. Blue: full signal; red: band-pass filtered signal containing geophysical information.

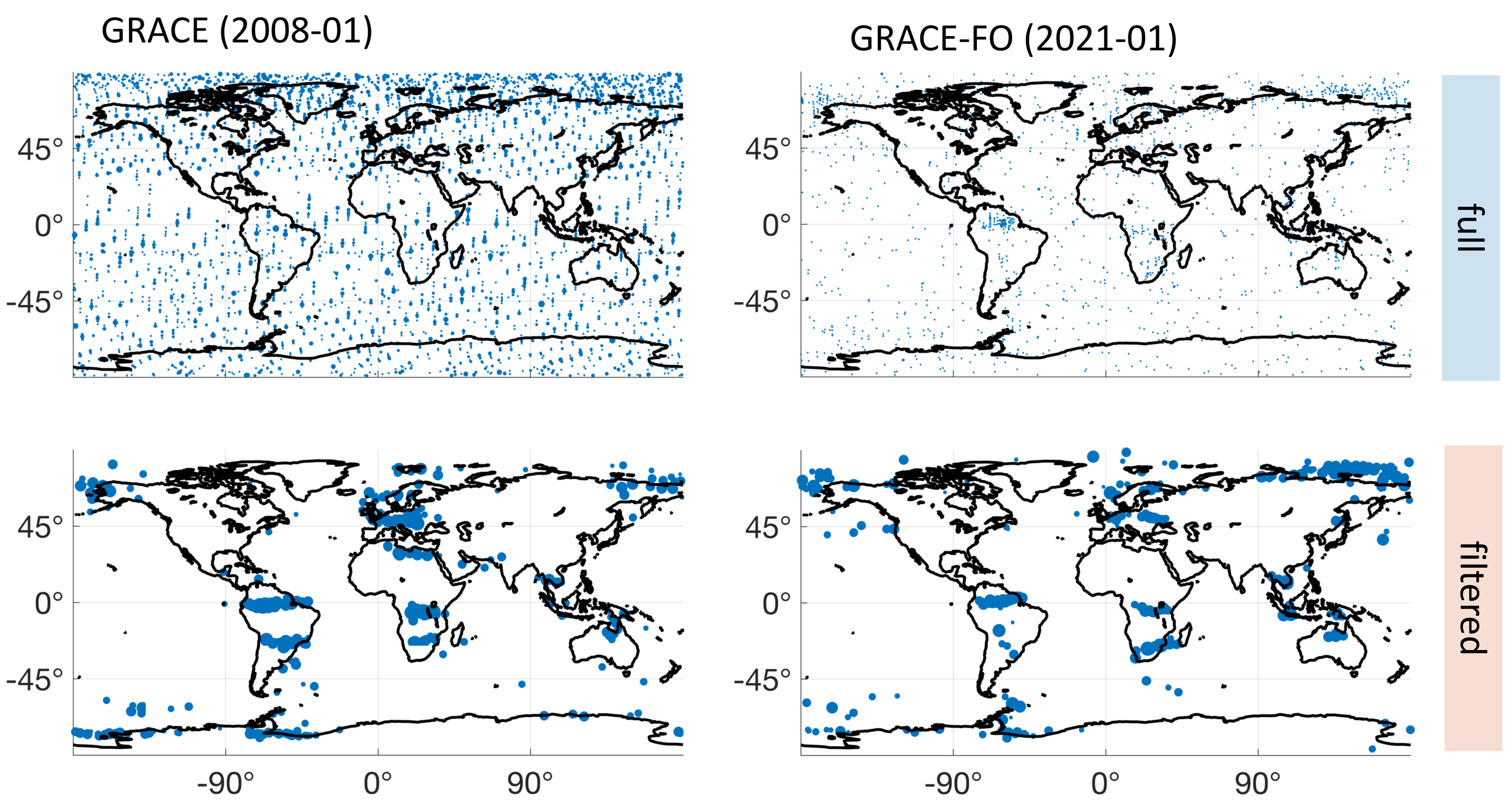
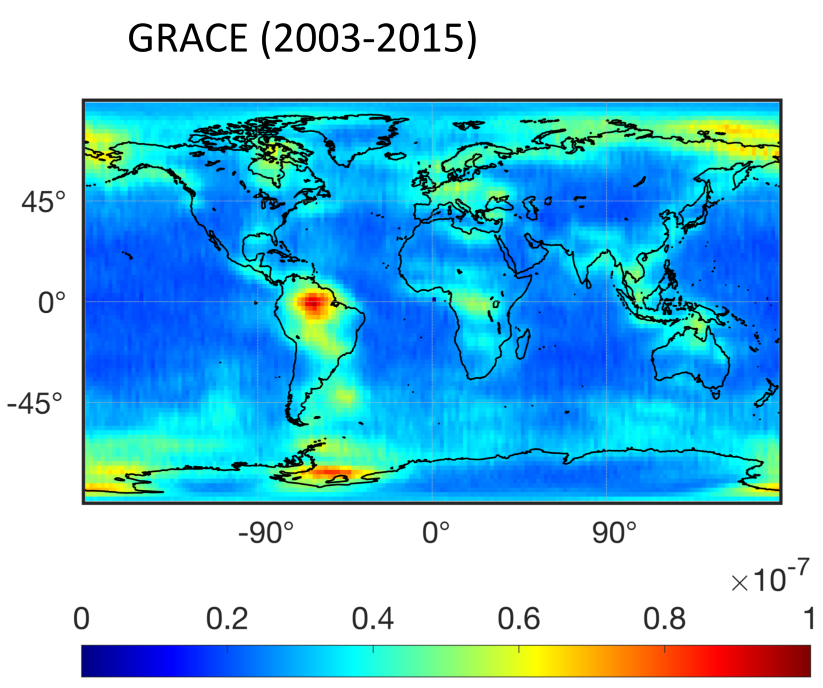


Fig. 3: Location of residuals with amplitudes larger than 3 sigma w.r.t. the mean value. Arcs were reduced to midpoints. The point size is proportional to the length of the arc.

4. Mean Filtered Residuals



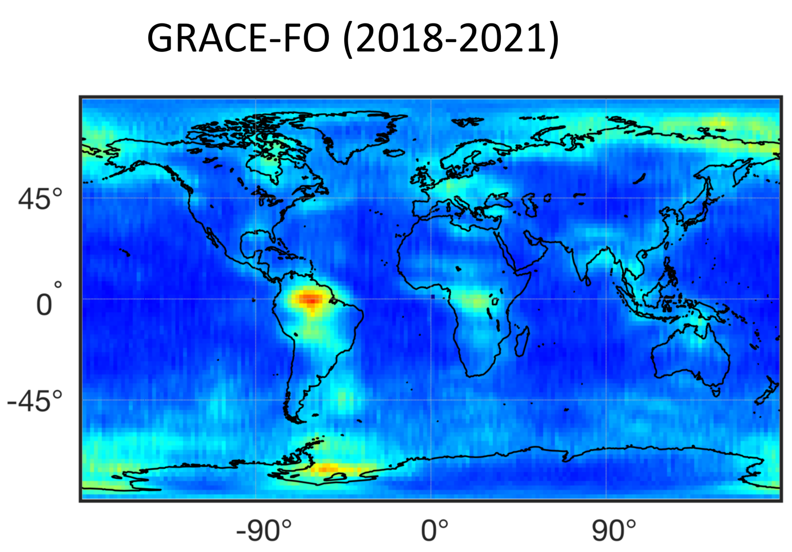


Fig. 4: Mean of absolute filtered K-band range-rate post-fit residuals. Band: 1-9 mHz. Colorbar in m/s.

5. K-band Range-Accelerations

- For the purpose of a better localization of the geophysical effects, we will have a look on K-band range-accelerations. We band-filter the range-rate residuals from 5e-7 Hz to 5 mHz. Then the filtered range-rate residuals are numerically differentiated with the help of a moving window polynomial of degree 6.

6. Regional Analysis of Range-Accelerations

- The residual range-accelerations are analyzed in four exemplary regions (see Fig. 5).

  For each region a daily RMS of the range-acceleration residuals is computed (see Fig. 6).

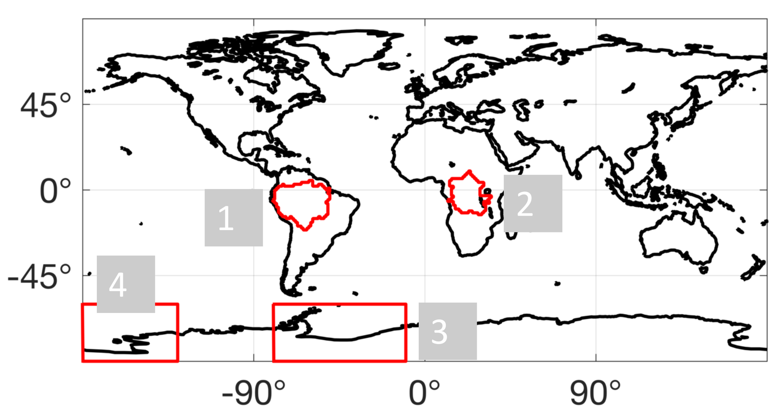


Fig. 5: Boundaries of the four inspected regions.

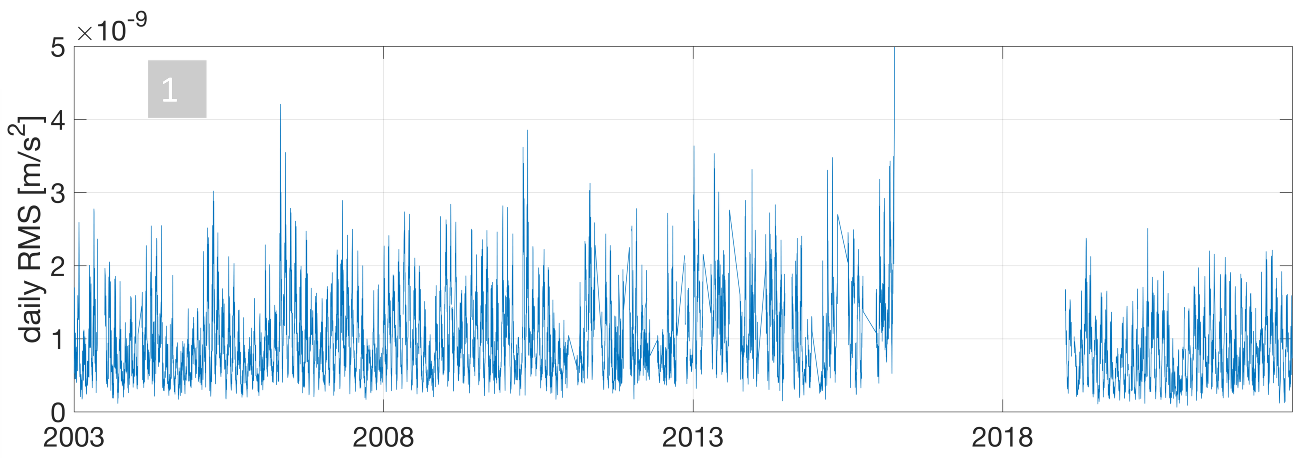


Fig. 6: Time series of regional daily RMS of range-accelerations in the Amazon basin.

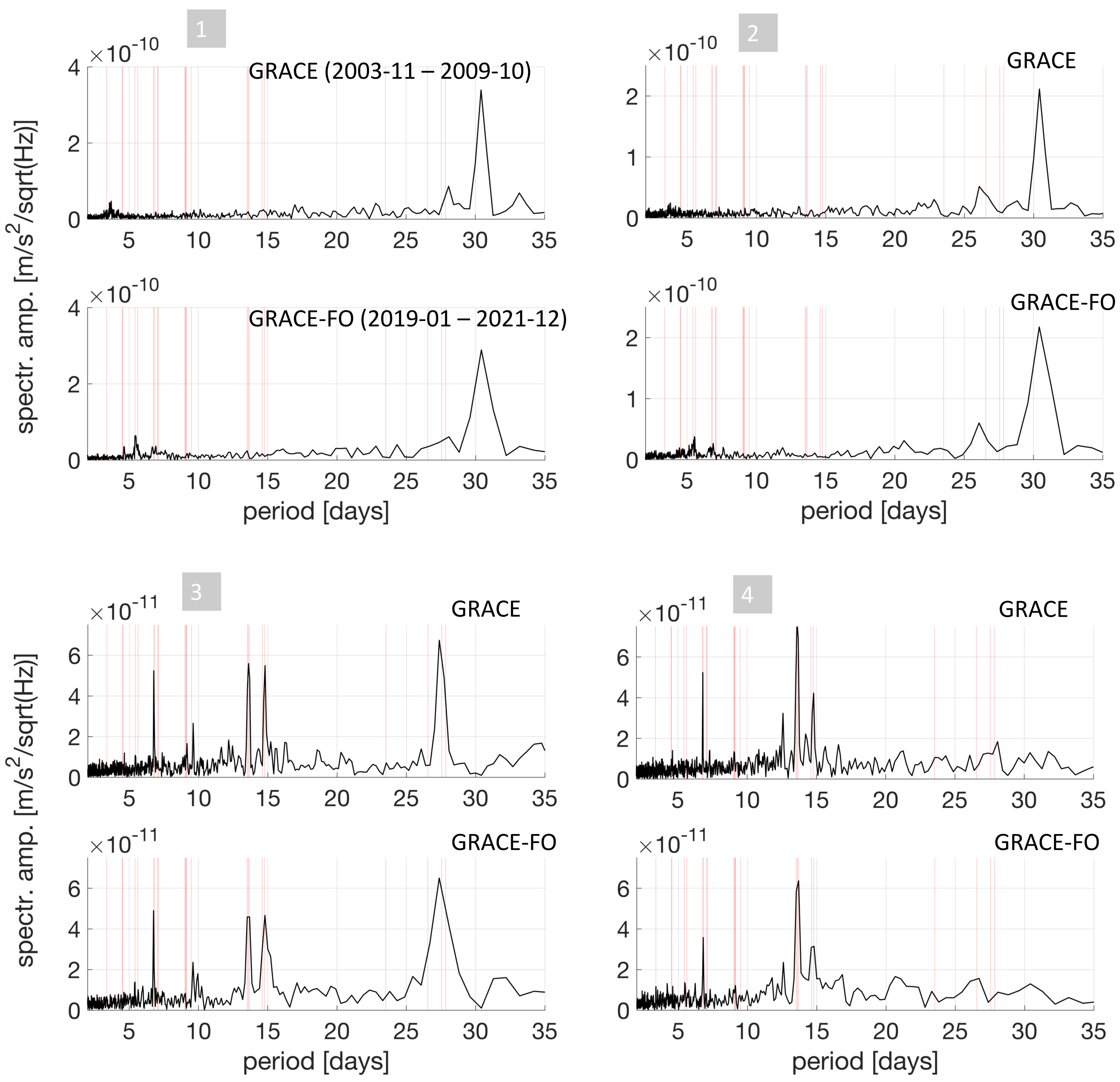


Fig. 7: Spectral amplitudes of regional daily RMS values in the four regions (periods 2-35 days). Vertical red lines represent periods and aliasing periods of the FES2014 constituents.

7. Conclusions

- Studying GRACE and GRACE-FO range-rate and range-acceleration post-fit residuals is important for understanding residual tidal and non-tidal mass variations.

References

[1] ***Koch, I. et al.* (2021):** Earth's Time-Variable Gravity from GRACE Follow-On K-Band Range-Rates and Pseudo-Observed Orbits, Remote Sensing, 13(9), 1766, doi.org/10.3390/rs13091766

[2] ***Lyard, F. H. et al.* (2021):** FES2014 global ocean tide atlas: design and performance, Ocean Science, 17(3), doi.org/10.5194/os-17-615-2021

[3] ***Dobslaw, H. et al.* (2017):** A new high-resolution model of non-tidal atmosphere and ocean mass variability for de-aliasing of satellite gravity observations: AOD1B RL06, Geophysical Journal International, 211(1), doi.org/10.1093/gji/ggx302

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