

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2
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Review on hess-2022-43

Henryk Dobslaw (Referee)

Referee comment on "Scaling methods of leakage correction in GRACE mass change estimates revisited for the complex hydro-climatic setting of the Indus Basin" by Vasaw Tripathi et al., Hydrol. Earth Syst. Sci. Discuss.,
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I read with interest the manuscript

Scaling methods of leakage correction in GRACE mass change estimates revisited for the complex hydro-climatic setting of the Indus basin

written by Vasaw Tripathi and colleagues. The paper addresses the problem of spatial leakage in satellite gravimetry data which arises from the limited ability of sensor data from low-low satellite tracking to accurately resolve steep spatial gradients in surface mass anomalies at scales of a few hundred kilometers and smaller. The resulting systematic error (called spatial leakage) is often mitigated by means of scaling approaches, and the current article is following this avenue of research with a special emphasis on the Indus Basin. The paper is generally well written and complements the existing literature on applications of satellite gravimetry data in this catchment. The study moreover fits nicely into the scope of the journal so that acceptance might be recommended as soon as a number of concerns outlined below are properly addressed.

(1) Rescaling (as performed in this study) is typically applied to allow for regional or even small-scale applications of the GRACE data. For the whole Indus catchment of about 1 million square kilometers, the effect of rescaling should be rather minor (which is also confirmed in the present work by the rather small changes in the time-series when moving from Figure 4 to Figures 14 and 15). It would be thus imperative to discuss in more detail the re-scaled GRACE-results presented in Figure 13, and also to compare them to the CSR mascons pixel by pixel. Note that I do not expect that rescaling will lead to a perfect match with the Mascons, nor do I suggest that the Mascons should be considered as the error-free truth in such an exercise. Instead, it would be important to carve out more explicitly any benefits of applying an elaborate rescaling scheme in lieu of simply downloading and applying the Mascons.

(2) A central result of this study are the scaling factors given in Figure 10. Table 4 gives a nice overview on the interpretation, which should be also reflected in the color scale selected for the figure. Please consider something like bright red or purple for all pixels with zero or even negative scaling, and neutral colors (green or white) for coefficients around one.

(3) Data-driven methods to account for spatial leakage have been proposed in the past by some of the authors (e.g., 10.1002/2017WR021150), and such methods are now routinely applied to approximate spatial leakage in surface mass estimates obtained from GRACE spherical harmonics solutions as disseminated via gravis.gfz-potsdam.de. Since Gaussian filtering is readily available to all the authors of the present paper, it would be quite straightforward to additionally explore the usage of twice-filtered GRACE GSM fields for the assessment of spatial leakage in the Indus Catchment. I believe that such an additional experiment could nicely complement the existing material.

(4) I understand that spatially distributed in situ data is not readily available in a transboundary basin like the Indus catchment. In such a situation, a common approach to demonstrate the applicability of a new method developments would be the usage of simulated sensor data and satellite products, where the true mass variability entering the simulations is known (see, e.g., 10.1007/s10712-015-9338-y). In such a simulation environment, it could be demonstrated to what extent rescaling as proposed here mitigates the adverse effects of spatial leakage.

(5) I am not quite convinced that frequency-dependent scaling (as proposed here) will be "useful for applications requiring a high signal-to-noise ratio". After all, it is any deviation from the seasonal cycle related to either interannual climate variations or hydrometeorological extremes that is of particular interest in many applications of remote sensing data. I do not find arguments in the paper that would help restoring leakage for such signals, so please elaborate your claim a little further.

A number of minor points might be additionally considered during the revision:

line 29: It is surprising to find a PhD thesis cited for such a rather general statement. In case you would like to give credit to the work of this author specifically, please consider citing any of her research papers.

Line 44: Authors should understand that even perfect dealiasing models will not remove all spatially correlated errors. On the contrary, simulation studies (10.1007/s10712-015-9338-y) demonstrate that background model errors in tides and sensor noise of the GRACE accelerometers have an almost similarly large effect on accuracy and spatial resolution of the GRACE monthly solutions available today. This also applies to GRACE-FO, where one of the accelerometer instruments performs worse than expected.

Line 49: Spatial leakage errors do not occur from the truncation of the spherical harmonics expansion but from the limited resolution of the along-track sensor data and the upward continuation of the gravity field from the surface to the orbital height of the satellites. Further, there is some inherent smoothing in the sensor data pre-processing that also reduces spatial gradients in the resulting gravity field estimates. Expanding the cutoff degree will certainly not solve the leakage issues, but render the inversion problem ill-posed.

Line 97: dependent

Line 104: Incomplete sentence. I assume that those glaciers are additionally feeding the Indus via tributary rivers?

Table 1: I am not convinced that "Integrated WGHM" is a very intuitive name for this model experiment. What about WGHM+GGM?

Line 249: In Table 1, eight different model experiments are listed: Please explain more explicitly why just two of them are applied in the following.