Constraining monthly GRACE-solutions with hydrological mass estimates

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1. Hydrology and GRACE

The GRACE satellite mission provides high resolution time-variable gravity-field information, which has considerably improved the knowledge of mass distribution and redistribution. In terms of hydrological applications, GRACE provides information on monthly changes of continental water storage. This information can be used in the continental water balance equation given below:

\[ P - R - ET_a \approx \frac{\partial S}{\partial t} \]  

(1)

Precipitation \( P \) − Run-off \( R \) − Actual Evapotranspiration \( ET_a \) − Water storage change

It was thought that such information could be used for calibrating hydrological models. However, GRACE has not met the expected level of accuracy. This inaccuracy is the contribution of the large errors due to aliasing in the higher harmonics degrees of the GRACE solutions. In order to counteract these erroneous higher harmonic degrees, various filtering techniques tailor-made for GRACE data have been developed. While these filters remove noise they also remove a good part of the signal. So, these filtered structures of GRACE covariance matrices were used in the analysis. It is evident from figures 3(a) and 3(b) that using only the block-diagonal covariance information; and (d) only variance information of the GRACE solutions.

In figures 2(b), 2(c), and 2(d) the constraints that were applied to GRACE solutions have taken care of the noise in the regions where they were applied and also smoothing out some of the adjacent areas.

Finally, to verify the constrained estimates a closed-loop analysis was carried out. The mass estimates from the constrained and unconstrained GRACE solutions for the twenty-eight catchments were compared with the corresponding hydrological mass estimates.

3. Results and Discussion

In figures 4(a) and 4(b) that using only the block-diagonal covariance information of GRACE is as good as using the full covariance information of GRACE.

3.1. Mass constraints from hydrology

Mass constraints from reliable hydrology data can be used for improving the signal quality of GRACE. The constrained signal can be used without further filtering. Hydrology contributes significantly for improving the signal content in the higher harmonic degrees. It has to be investigated as to how the hydrological mass constraints map into the higher harmonic degrees. Simulated block diagonal covariance matrices were shown to closely approximate the simulated full covariance matrices.

Additional reliable data sources other than hydrology can also be used for constraining GRACE solutions.


References