Response to Referee 2:
Using GRACE to derive corrections to precipitation data sets and improve modelled snow mass at high latitudes

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We thank the reviewer for their comments and suggestions. In response to the questions raised:

Page 4, Line 31-32: We have compared the basin areas of our 1° resolution river basins with the basin areas quoted in the GRDC dataset (these are the areas draining to the station nearest to the basin outflow, see Table 1 below). The difference is a few percent for each basin. The biggest difference is in the Lena, where our basin area is 6% smaller than the GRDC area.

Basin	GRDC basin area (km ^{2})	TRIP basin area (km ^{2})	Difference
Yenisei	2440000	2492975	+2%
Ob	2949998	2920094	-1%
Lena	2460000	2315590	-6%
Mackenzie	1660000	1721400	+4%

Table 1: Areas of river basins draining to the GRDC station, as given by the GRDC data set [1] and by the river basins from the 1° TRIP river network [2]. The final column shows the percentage difference between the TRIP and the GRDC areas.

Page 6, Section 2.2: GRACE RL05 is the set of spherical harmonic solutions. We follow the recommendation of [3] and use the mean of the the three available solutions to effectively reduce the uncertainty, rather than using the single mascon solution.

Page 7, Section 2.4: We decided that it would be better to use a best estimate of evaporation in these basins, rather than using something that is known to be wrong (zero cold season evaporation). GLEAM is a model output, but it is well established and based on gridded observational data sets that are independent of the data that we are investigating in this analysis.

In developing this analysis, we also investigated the use of the LandFlux-EVAL dataset (a synthesis of diagnostic, land-surface model, global hydrological model and reanalysis ET estimates) [4], as well as using JULES output ET. LandFlux-EVAL only has a few years in common with the GRACE timeseries, so could not be used for the whole analysis. We did not want to use JULES output as this is not independent of the precipitation data that we are trying to investigate.

We will add some discussion of this, as well as the inherent uncertainties in the observational products to the revised text.

Page 11, Equation 5-6: These formulations are equivalent. We have chosen to use the one that demonstrates the way that we have combined the other products to obtain an estimate of precipitation, so would prefer to keep this as is.

Page 12, Section 4.3: Yes, it would be a useful exercise to see the effect of using this scaling for the whole year. Of course, it should not be relied upon as a definitive scaling for the summer precipitation, and one would expect that the underestimation in summer precipitation results from different processes. But it would be interesting to see the effect of using our cold season scaling for the whole year and it would give an indication of the size of the required scaling for the summer precipitation that would result in better discharge simulations. We will do this experiment and will include the results in the supplementary information.

Page 17, Line 19: Yes, we will do this.

References

[1] GRDC. The global runoff data centre, 2014. URL `https://www.bafg.de/GRDC`. 56068, Koblenz, Germany. Accessed: 2014-09-01.

[2] Taikan Oki and Y. C. Sud. Design of total runoff integrating pathways (trip)âĂŤa global river channel network. *Earth Interactions*, 2(1):1–37, 1998. doi:10.1175/1087-3562(1998)002<0001:DOTRIP>2.3.CO;2.

[3] C. Sakumura, S. Bettadpur, and S. Bruinsma. Ensemble prediction and intercomparison analysis of grace time-variable gravity field models. *Geophys. Res. Lett.*, 41(5):1389–1397, March 2014. ISSN 0094-8276. doi:10.1002/2013gl058632.

[4] B. Mueller, M. Hirschi, C. Jimenez, P. Ciais, P. A. Dirmeyer, A. J. Dolman, J. B. Fisher, M. Jung, F. Ludwig, F. Maignan, D. G. Miralles, M. F. McCabe, M. Reichstein, J. Sheffield, K. Wang, E. F. Wood, Y. Zhang, and S. I. Seneviratne. Benchmark products for land evapotranspiration: Landflux-eval multi-data set synthesis. *Hydrology and Earth System Sciences*, 17(10):3707–3720, 2013. doi:10.5194/hess-17-3707-2013.