Relating Satellite Gravimetry Data To Global Snow Water Equivalent Data

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Fig. 1a: Correlation total period

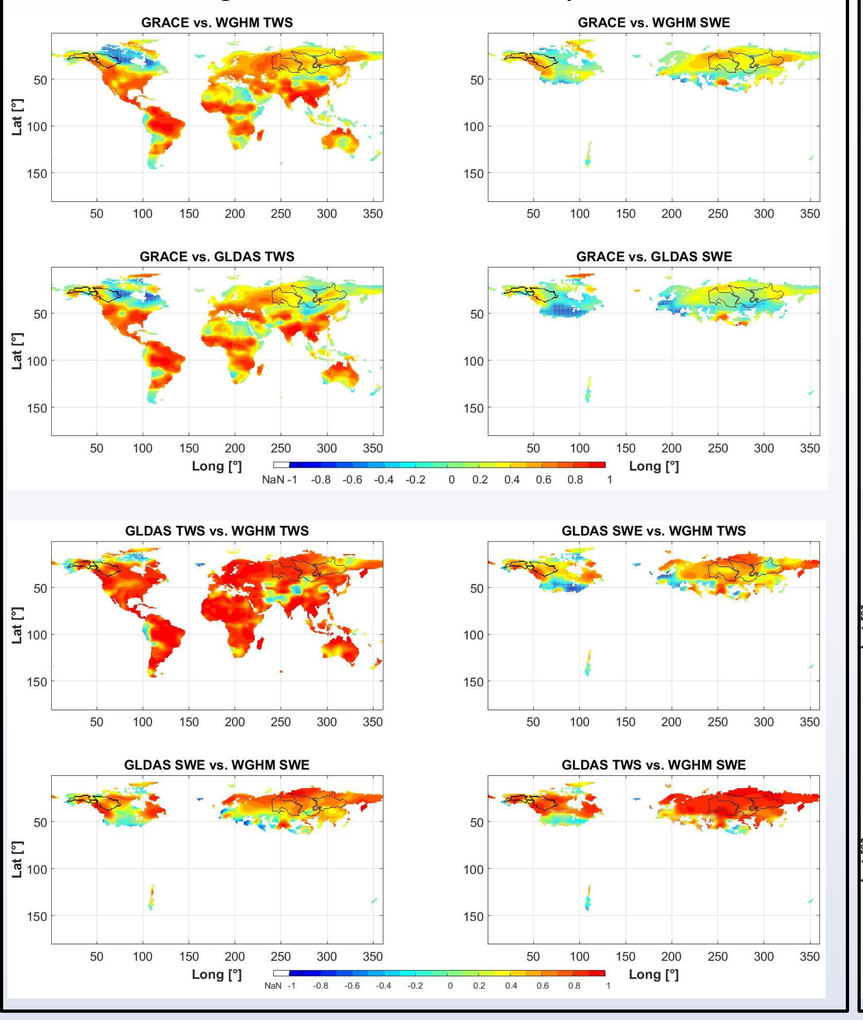


Fig. 1b: Correlation winter period

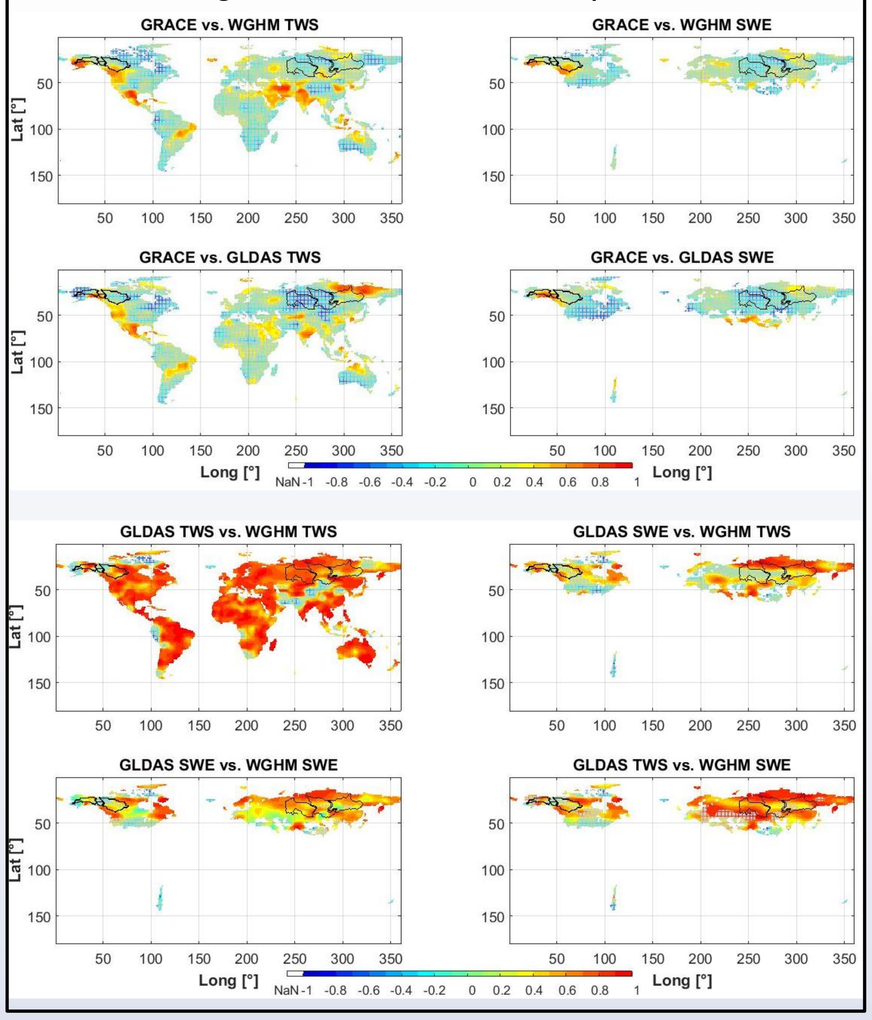
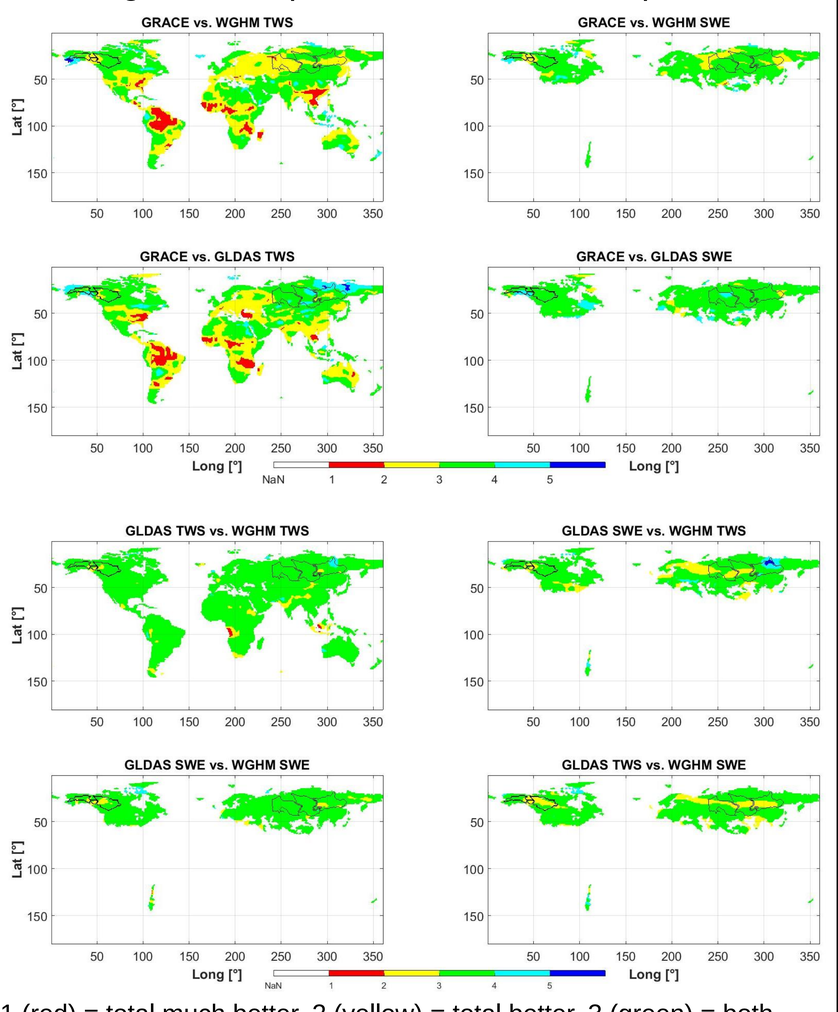


Fig. 1c: Comparison total vs. winter period

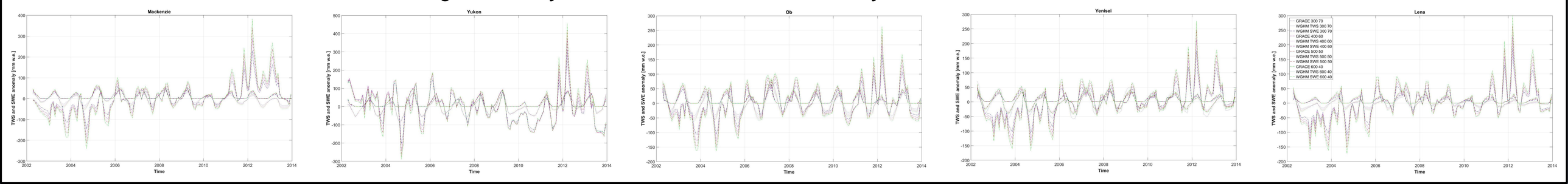


1 (red) = total much better, 2 (yellow) = total better, 3 (green) = both equal, 4 (light blue) = winter better, 5 (dark blue) = winter much better

Snow is an important factor for the evolution of permafrost. Not only timing and length of duration of the snow cover are important but also snow height. This can be extracted using snow water equivalent (SWE) data. Gravimetric GRACE satellite data measures changes in total water storage (TWS) but cannot distinguish between different sources. The benefit of GRACE data is to receive a direct measured signal. Therefore, other data are necessary to extract the different compartments.

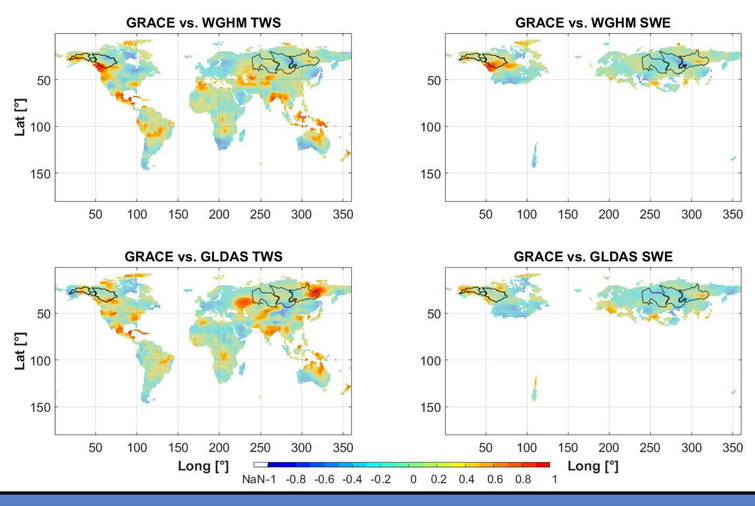
In this study, the hydrological model WGHM (TWS and SWE) and the land surface model GLDAS (TWS and SWE) are used. All data have to be pre-processed in the same way as the GRACE data to be comparable. A correlation analysis was performed between the different products assuming that changes in TWS can be linked to changes in SWE if either SWE is the dominant compartment of TWS or if SWE changes proportionally with TWS.
Spatial extent was focused on five river catchments in the permafrost areas in North America (Mackenzie, Yukon) and Siberia (Ob, Yenisei, Lena). The correlation was performed for the total period (April 2002 – December 2013) and the winter months of this period (December – April) (Fig. 1a and b). The comparison (Fig. 1c) shows that the correlation of the total period to the correlation of the winter period is mostly equal or that the correlation of the total period fits better in some parts of the river catchments.

Fig. 2: Monthly values of TWS and SWE anomaly for the five river catchments



Monthly values of WGHM TWS and WGHM SWE with different settings for the pre-processing in the five river catchments show a uniform periodically annual pattern (Fig. 2). GRACE data show the same pattern between 2006 and 2011 but have more peak values in the beginning and the end of the study period. Therefore, a correlation was performed for the shorter period 2006 until 2011 to see if GRACE data is higher correlated to the WGHM and GLDAS data compared to the total period.

Fig. 3: Correlation short period

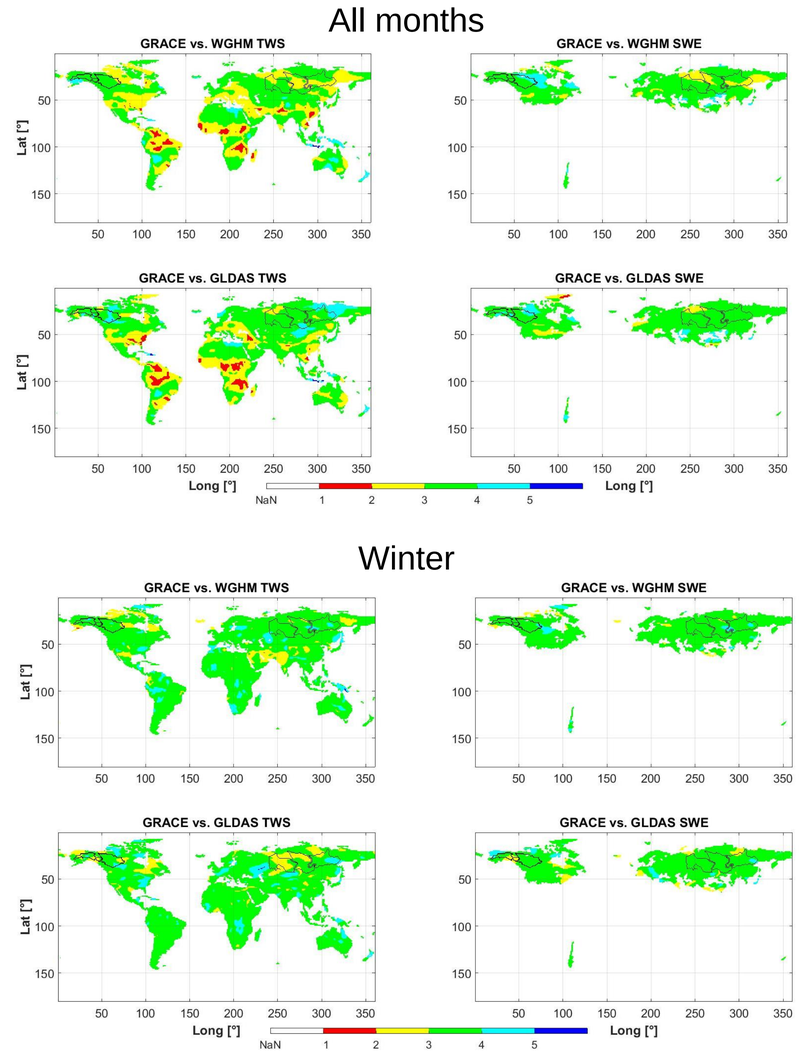


The correlation between GRACE and WGHM TWS/SWE and GLDAS TWS/SWE shows higher correlation coefficients for the total time compared to the short time (Fig. 3). The comparison between the total and the short time for all months and the winter time shows that the correlation of the total period to the correlation of the short period is mostly equal in the river catchments (Fig. 4). In some parts especially in Siberia, the correlation of the total period fits better compared to the short period. The correlation between WGHM and GLDAS for the short period does not change much compared to the total period (not shown).

The correlation of the monthly values of the river catchments improves a lot using the short time period (2006 – 2011), especially for the correlation of WGHM and GRACE data (Table 1). The peaks visible in the monthly values seem to have no influence on the pixel-based correlation or even improve this correlation.

Therefore, it is not clear from this analysis, if there is a significant correlation between the GRACE and the WGHM SWE and GLDAS SWE data in the five river catchments. A further analysis of the model input data and calculation and special events in the river catchments are necessary to answer this question.

Fig. 4: Comparison total vs. short (2006 – 2011) period



1 (red) = total much better, 2 (yellow) = total better, 3 (green) = both equal, 4 (light blue) = short better, 5 (dark blue) = short much better

Table 1: Correlation of monthly GRACE and WGHM TWS/SWE values in the five river catchments

River basins / Correlation	Mackenzie total	Mackenzie short	Yukon total	Yukon short	Ob total	Ob short	Yenisei total	Yenisei short	Lena total	Lena short
GRACE, WGHM TWS	0,24	0,46	0,55	0,65	0.59	0.69	0.41	0.49	0.53	0.53
GRACE, WGHM SWE	0,29	0,39	0,49	0,52	0.4	0.48	0.28	0.41	0.39	0.5
WGHM TWS, WGHM SWE	0,87	0,89	0,85	0,87	0.84	0.84	0.87	0.87	0.78	0.81

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