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Large-scale hydrological changes in North America and Scandinavia from GRACE

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The Gravity Recovery and Climate Experiment (GRACE) satellite mission has proven to be an invaluable tool in monitoring hydrological changes. Due to the fact that GRACE detects combined mass changes from different sources, dedicated hydrological studies, however, have been mainly limited to areas where the GRACE signal is assumed to be solely related to hydrology or where other overlapping processes can be removed as accurately as possible. In North America and northern Europe, the dominating glacial isostatic adjustment (GIA) signal is shadowing water storage changes. Here, modeled GIA data are used for removal, but model imperfections contaminate the hydrology signal.

With a new separation approach we are able to self-determine the hydrological contribution in North America and northern Europe from GRACE and GPS data (Wang et al., 2012). The separation of the hydrological signal is not GIA model dependent and thus provides a clear picture of water storage changes in those areas free of the usually large remnant GIA contributions. From August 2002 to March 2011, the derived mass increase in central North America is about 43.0$\pm$5.0 Gt/yr. This is about three quarter of all water falling down Niagara Falls every year. Average groundwater variations from wells in Alberta and central Saskatchewan are in very good agreement to our result and show a significant increase from the year 2002 on. Before that year, there is a significant drop in water levels beginning in 1999/2000, which is related to a drought in the Canadian Prairies during these years. The increase from about 2003 on can be interpreted as the recovery of the water storage after the drought. As the GRACE observation period begins during that time, GRACE exactly observes this recovery in form of a significant mass increase. Changes in water levels from tide gauges for the Great Lakes and groundwater wells in the Lower Peninsula of Michigan also agree to our findings.

At the southern tip of the Scandinavian Peninsula, the mass gain is about 2.3$\pm$0.8 Gt/yr, a much lower signal than in central North America. Water-level variations from both lakes Vänern and Vättern and from groundwater well data show positive trends since the low in years 2002 and 2003 consistent with our estimated mass increase.

Our presentation will show the clear identification of these current large-scale hydrological changes in GIA-affected areas with our approach. We further demonstrate the capabilities of GRACE and its follow-on missions for such studies, and also how we can help to improve global hydrology models, to investigate floods and droughts and to control water storage in large lakes.

Reference

Wang, H.S., L. Jia, H. Steffen, P. Wu, L. Jiang, H. Hsu, L. Xiang, Z. Wang, and B. Hu (2012): Increased water storage in North America and Scandinavia from GRACE gravity data, Nature Geosci., doi:10.1038/NGEO1652.