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Relating GRACE terrestrial water storage variations to global fields of atmospheric forcing

Vincent Humphrey, Lukas Gudmundsson, and Sonia Isabelle Seneviratne

Federal Institute of Technology Zürich, Institute for Atmospheric and Climate Science, Switzerland
(vincent.humphrey@env.ethz.ch)

Synoptic, seasonal and inter-annual fluctuations in atmospheric dynamics all influence terrestrial water storage, with impacts on ecosystems functions, human activities and land-climate interactions. Here we explore to which degree atmospheric variables can explain GRACE estimates of terrestrial water storage on different time scales. Since 2012, the most recent GRACE gravity field solutions (Release 05) can be used to monitor global changes in terrestrial water storage with an unprecedented level of accuracy over more than a decade. In addition, the release of associated gridded and post-processed products facilitates comparisons with other global datasets such as land surface model outputs or satellite observations. We investigate how decadal trends, inter-annual fluctuations as well as monthly anomalies of the seasonal cycle of terrestrial water storage can be related to fields of atmospheric forcing, including e.g. precipitation and temperature as estimated in global reanalysis products using statistical techniques. In the majority of the locations with high signal to noise ratio, both short and long-term fluctuations of total terrestrial water storage can be reconstructed to a large degree based on available atmospheric forcing. However, in some locations atmospheric forcing alone is not sufficient to explain the total change in water storage, suggesting strong influence of other processes. Within that framework, the question of an amplification or attenuation of atmospheric forcing through land-surface feedbacks and changes in long term water storage is discussed, also with respect to uncertainties and potential systematic biases in the results.