Geophysical Research Abstracts,
Vol. 11, EGU2009-8866, 2009
EGU General Assembly 2009

Improved process representation in a global hydrological model by calibration with GRACE gravity data

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Global data of temporal water storage variations are derived from monthly gravity measurements of the GRACE (Gravity Recovery And Climate Experiment) satellite mission, which completes its seventh year of operation (2002-2009). Therefore, GRACE provides a valuable input for validation and calibration of large-scale hydrological models. In this study, we present a technique to apply GRACE data for the parameter tuning of a global hydrological model, the WaterGAP Global Hydrology Model (WGHM). An efficient multi-objective calibration framework was developed to constrain model predictions by both measured river discharge and water storage variations from GRACE. Model calibration was done for WGHM for the 22 largest river basins worldwide. It is shown that the approach leads to improved simulation results with regard to both objectives, e.g. for the Amazon, Mississippi and Congo. From the multi-objective approach we gain more reliable and consistent simulations of water storage variations within the continental water cycle and detect possible model structure errors or mis-modeled processes for specific river basins. These results lead to an improved understanding of hydrological processes and their representation in the global model. Finally, we analyze the robustness of our results with respect to GRACE measurement errors, uncertainties from different gravity solutions and different filter techniques. Our results highlight the valuable nature of GRACE data when merged into large-scale hydrological modeling and depict methods to improve large-scale hydrological models.