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Landscape-scale water balance monitoring with an iGrav superconducting gravimeter in a field enclosure

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In spite of the fundamental role of the landscape water balance for the Earth's water and energy cycles, monitoring the water balance and its components beyond the point scale is notoriously difficult due to the multitude of flow and storage processes and their spatial heterogeneity. Here, we present the first deployment of an iGrav superconducting gravimeter (SG) in a minimized field enclosure on a grassland site for integrative monitoring of water storage changes. Results of the field SG were compared to data provided by a nearby SG located in the controlled environment of an observatory building. For wet-temperate climate conditions, the system proves to provide gravity time series that are similarly precise as those of the observatory SG. At the same time, the field SG is more sensitive to hydrological variations than the observatory SG. We demonstrate that the gravity variations observed by the field setup are almost independent of the depth below the terrain surface where water storage changes occur (contrary to SGs in buildings), and thus the field SG system directly observes the total water storage change, i.e. the water balance, in its surroundings in an integrative way. We provide a framework to single out the water balance components actual evapotranspiration and lateral subsurface discharge from the gravity time series on annual to daily time scales. With about 99% and 85% of the gravity signal originating within a radius of 4000 and 200 meter around the instrument, respectively, this setup paves the road towards gravimetry as a continuous hydrological field monitoring technique at the landscape scale.