REMOTE SENSING OF SMALL RESERVOIRS: REGIONAL INVENTORIES, ASSESSMENT OF STORAGE VOLUMES, AND CALIBRATION OF HYDROLOGICAL MODELS

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ABSTRACT

Small reservoirs are important sources of water supply for the scattered rural population in semi-arid areas. Large numbers of such reservoirs have been built for decades, but, as a result of diverse sponsorship, and often poor record keeping, little information and baseline data is available. The number of small reservoirs in certain regions, their storage volumes, and their hydrological impact are often unknown. Despite their importance for the rural population, such reservoirs have not been studied extensively, because their small sizes and their existence in large numbers complicate their surveying. The presented study showcases the advantages and shortcomings of optical and radar system to inventory and monitor small reservoir storage, and shows how radar based reservoir storage volume monitoring is used to calibrate hydrological models which allow to assess reservoir impact on runoff.

Remote sensing poses an ideal tool to make inventories of small reservoirs over larger regions, where the information on small reservoirs is not available or outdated. In various regions of Africa it has also been shown that, despite the various shapes of the reservoirs, small reservoir storage volumes can be estimated well as a function of their surface areas [1, 2, 3, 4]. This allows us to estimate and monitor small reservoir storage volumes with satellite images.
Reservoir surface areas can be extracted from both optical, and radar images. Both of them have their advantages and shortcomings. Optical data is simple to use, and especially suitable for inventories. When multi-temporal acquisitions are required, radar remote sensing is a promising alternative as radar systems are not affected by frequently cloudy conditions, and have a higher repeated coverage. The extraction of small water bodies from individual radar scenes is affected by other factors, such as vegetation context, and wind-induced waves and ripples causing Bragg scattering.

To assess the suitability of ENVISAT ASAR as a tool to extract small reservoir surface areas, the surface extents of three reservoirs were determined from monthly ENVISAT ASAR images from June 2005 until August 2006. Radar remote sensing of small reservoirs proves suitable especially during the rainy season, but is affected by wind and lack of vegetation context during the dry season. Reservoirs could be extracted from the radar images most often with a quasi-manual classification approach, as stringent classification rules often failed under less than optimal conditions [5]. Failure to extract reservoirs was due to the backscattered radar signal that occurred above wind speeds of 2.6 m s−1 (Bragg scattering). The analysis of 15 months of wind speed data recorded at the time of image acquisitions shows that due to lower wind speeds at the time of the evening overpass, the use of night time acquisitions was more effective than the use of daytime images.

Time series of remotely sensed small reservoir surface areas, translated into storage volume changes, were successfully used to calibrate hydrological rainfall-runoff models [6]. Eight small reservoirs in the Upper East Region of Ghana, and Togo, were monitored to calibrate modified Thornthwaite-Mather models, in which increasing precipitation leads to exponentially increasing contributing areas. The model results indicate that the overall impact of the reservoirs largely depends on the ratios of reservoir and watershed areas. For this two year study, the reservoirs captured on the average 34% of quick flow, and 15% of overall watershed runoff.

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