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Monitoring small reservoirs in semi-arid region by satellite SAR data

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The work presents a novel tool for the monitoring of small reservoirs in semi-arid regions. The pilot project was developed in the Yatenga region, a Sahelian area in northern Burkina Faso. In semi-arid regions, small reservoirs are widely employed for facing seasonal variability in water availability due to the alternation of a rainy (3 months) and a dry (9 months) season. Beside their crucial importance, the small reservoirs are not appropriately monitored, they are often built for the initiative of small local communities and even basic data as their location and capacity are not available. Another major problem is linked to soil erosion due to water and consequent reservoirs' sedimentation that reduces the amount of available water and the life span of reservoirs.
This lack of data prevents the implementation of strategies for the optimization of water resources management. It is therefore necessary to improve the data availability through the development of cost-effective monitoring techniques and to adapt the hydrological modeling to the limited available data.
In this context the use if satellite data can highly contribute to the achievement of crucial information at low costs, high resolution in time and wide areas. In the present work, we used COSMO-SkyMed Stripmap (3m resolution) and Spotligth (1m resolution) Synthetic Aperture Radar (SAR) data acquired under the aegis of the 2007 Italian Space Agency Announcement of Opportunity and of the HydroCIDOT project.
The shorelines of the reservoirs were extracted from the series of SAR images by employing an innovative change-detection framework. A digital elevation model (DEM) of the study area was obtained via standard interferometry processing of images acquired at the end of the dry season, when small reservoirs are completely empty, and information about the surface usually covered by water can be retrieved.
The obtained DEM and shorelines were used for bathymetry extraction of reservoirs. For the verification of the DEM accuracy, the contour lines obtained by the DEM were compared to the shorelines of the reservoirs. In this way it was possible to verify a SAR product by the means of another SAR product, without the need of expensive field campaigns.
The actual reservoir capacity was obtained from the DEM using Geographic Information System (GIS) tools. The comparison with the original capacity in the year of construction of the reservoirs showed that in about 25 years most of the reservoirs lost from 50 to 100 % of their original capacity. The estimated sedimentation rates combined with the DEM-based identification of the drained catchments, allowed the estimation of the average soil erosion at catchment scale.
The time evolution of volumes retained at reservoirs is detected by superimposing the shoreline to the DEM. With the developed technique, a synoptic view of the total water volume available in the reservoirs of an entire region can be provided.
The information on retained water volumes is used as a surrogate of runoff gauges measurements. This possibility is crucial as, in developing countries hydrological data, and particularly runoff measurements are often non available. The obtained results are used to validate an hydrological model.