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Discharge estimation in arid areas with the help of optical satellite data

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The MENA region is facing severe water scarcity. Overexploitation of groundwater resources leads to an ongoing drawdown of the water tables, salinisation and desertification of vast areas. To make matters worse enormous birth-rates, economic growth and refugees from conflict areas let the need for water explode. In the context of climate change this situation will even worsen and armed conflicts are within the bounds of possibility.

To ease water scarcity many innovative techniques like artificial groundwater recharge are being developed or already state of the art. But missing hydrological information (for instance discharge data) often prevents design and efficient operation of such measures. Especially in poor countries hydrological measuring devices like gage stations are often missing, in a bad status or professionals of the water sector are absent. This leads to the paradox situation that in many arid regions water resources are indeed available but they cannot be utilised because they are not known.

Nowadays different approaches are being designed to obtain hydrological information from perennial river systems with the help of satellite techniques. Mostly they are based on hydraulic parameters like river dimensions, roughness and water levels which can be derived from satellite data. By using conventional flow formulas and additional field investigations the discharge can be estimated. Another methodology derived information about maximum flow depth and flow width from optical sensors of high resolution to calculate discharge of the rivers whilst the flood.

Attempts to derive discharge information from structural components of the river and fluviomorphologic changes due to changing flow regimes are in the focus of recent research. One attempt used Synthetic Aperture Radar (SAR) data to estimate discharge in braided river systems. Other attempts used airborne SAR imagery to obtain information about sinuosity and total river width of perennial braided river systems which were related to specific discharges.

Such approaches cannot be applied in arid areas with ephemeral discharges.

In this groundbreaking proposal, discharge data for arid riverine landscapes (dry wadi systems) will be derived from remotely sensed structural patterns and fluvio-morphologic changes. The main idea of the research work is as follows:

In arid areas seldom precipitation events lead to flash floods which may significantly alter the geomorphology of a wadi river system. This is due to the mainly sparse vegetation cover in arid areas which enables mobilization and transport of large amounts of bed material whilst flood events. For example maximum river width of single channels, total river width of braided river networks and sinuosity of river beds change during a floods. Also river branches can be dislocated. These morphologic changes can be observed and judged from space. There is a correlation between intensity and duration of a flood and the resulting changes in riverbed structure. The kind of changes gives evidence about stream power and flow behaviour of the observed river systems.

Satellite images from date A are compared with data from date B regarding morphologic changes and specific river patterns. Satellite data of different spatial and spectral solutions will be used from environmental and commercial satellites such as Landsat, SPOT, ASTER, IKONOS and so on. If a change in river morphology can be observed it was due to a flood event.

Multitemporal analysis (change detection) with the help of digital image processing now enables to observe the nature and intensity of morphological changes. Structural patterns are extracted from the images and compared to field observations from the two exemplarily test sites in Jordan and Oman. Comprehensive field work was already performed to summarise detailed fluvial structures and to gather hydrologic data for each test site. The whole river networks will be visualised and extracted from the images with the help of spectral classification for further investigation such as fractal analysis of the river patterns.

The "Morphologic Activity Index (MAI)" combines the above acquired information to one specific parameter for the examined test site. MAI contains information about general river patterns, river energy and the behaviour of the river system. MAI will be necessary for calibrating the calculated river discharges with discharge measurements which were taken on ground whilst the flood.

With the available satellite images it will be possible to perform discharge estimation for duration of at least two or three decades.

Statistical approaches and time series analysis will allow deriving information about the general flow behaviour (e.g. repeat interval of discharge and probable maximum flood) which are essential for planning infrastructural measures.

First results from the test sites in Jordan and Oman showed the applicability of satellite data analysis regarding morphologic changes.

The goal of the presented research work is to develop a fast and economic methodology to derive spatial distributed discharge information for large and inaccessible arid areas.