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Estimation of Flow Discharge at Small to Large Size Streams Using the Sentinel-1 Synthetic Aperture Radar

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We propose a novel approach of estimating stream flow discharge in small to large size channels using the European Space Agency Sentinel-1 satellite data. Fifteen streams with difference sizes in the Han River basin, Korea were chosen as study sites, and a series of Sentinel-1 Synthetic Aperture Radar (SAR) images and the observed stream flow data were used to develop the methodology. The methodology relates the stream flow discharge to the water body area that is optimally filtered from the satellite images. Here, the satellite image analysis involves the following sequential procedures: (1) The SAR images for each test site were processed for radiometric calibration, speckle errors and terrain correction; (2) The histogram matching technique was applied to the stack of images to normalize the brightness intensity of all images; (3) The area in the satellite image to extract the water bodies from is manually delineated; (4) A single threshold value is applied to all the brightness-adjusted images to extract the waterbody; (5) the power-law relationship between the extracted waterbody area and stream flow discharge is established and the coefficient of determination (R2) of the relationship is calculated; (6) The process of (4) and (5) is repeated to obtain the threshold value of water body extraction that maximizes the R2 of the relationship. A clear relationship could be developed for the 13 stream locations except for the 2 of which flow is highly influenced by hydraulic structures such as dam. At these 13 stream locations, the R2 value of the power-law relationship between the satellite-based water body area and flow discharge varied between 0.47 and 0.98 with a mean value of 0.82. The relationship was influenced by the geometrical properties of the stream such as the size, side slope and the sensitivity of the waterbody area to the depth of flow.

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