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Shoreline to Height (S2H): an algorithm to monitor reservoirs' water height from satellite images. A flood risk management application

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In a reservoir, water level monitoring is important for emergency management purposes. This information can be used to estimate the degree of filling of the water body, thus helping decision makers in flood control operations. Furthermore, if assimilated in hydrological models and coupled with rainfall forecasts, this information can be used for flood forecast and early warning. In many cases, water level is not known (e.g. data-scarce environments), or not shared by operators. Remote sensing may allow overcoming these limitations, enabling its estimation.

The objective of this work is to present the Shoreline to Height (S2H) algorithm, developed to retrieve the height of the water stored in reservoirs from satellite images. To this aim, some auxiliary data are needed: a DEM and the maximum/minimum height that can be reached by the water. In data-scarce environments, these information can be easily obtained on the Internet (e.g. free, worldwide DEM and design data for artificial reservoirs). S2H was tested with different satellite data, both optical and SAR (Landsat and Cosmo SkyMed®-CSK®) in order to assess the impact of different sensors on the final estimates. The study area was the Place-Moulin Lake (Valle d'Aosta-VdA, Italy), where it is present a monitoring network that can provide reliable ground-truths for validating the algorithm and assessing its accuracy. When the algorithm was developed, it was assumed to be in absence of any "official"-auxiliary data. Therefore, two DEMs (SRTM 1 arc-second and ASTER GDEM) were used to evaluate their performances. The maximum/minimum water height values were found on the website of VdA Region. The S2H is based on three steps: i) satellite data preprocessing (Landsat: atmospheric correction; CSK®: geocoding and speckle filtering); ii) water mask generation (using a thresholding and region growing algorithm) and shoreline extraction; iii) retrieval of the shoreline height according to the reference DEMs (adopting a statistical approach). The algorithm was tested for different water heights and results were compared against ground-truths.

Findings showed that the combination CSK®-SRTM provided more reliable results. It was also found that the overall quality of the estimates increases as the water height increases, reaching an accuracy up to some centimetres. This result is particularly interesting for flood control applications, where it is important to be accurate when the reservoir's degree of filling is high. The potentialities of S2H for operational hydrology purposes were tested in a real-case simulation, in which the river discharge's prediction downstream of the dam was needed for flood risk management purposes. The water height value retrieved with S2H was assimilated within a semi-distributed, event-based, hydrological model (DRiFt) by using a simple direct insertion algorithm. DRiFt is usually run in operative way on the reservoir by using ground-truths as input data. The result of the data assimilation experiment was compared with the "real", operative run of the model. Findings showed a high agreement between the two simulations, proving the utility/quality of the S2H algorithm.

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