Title: Method for monitoring flow discharge in mountain rivers using non-contact instruments

Lab: IGE, HyDRIMZ team

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Key words: discharge, hydrometry, river, radar, LSPIV

Context and objectives of the internship:

Discharge is a fundamental variable of rivers which affects catchments, ecosystems and all hydrological and biogeochemical processes. Its measurement is vital for many human activities. However, the monitoring of discharge is not easy, especially in mountainous or alluvial rivers. In conventional hydrometric stations, the monitoring of discharge relies on water level. Stage-discharge (h-Q) rating curves are generally established by periods where the river bed remains stable, on the basis of gaugings completed eventually by hydraulic modelling. This well-proven method is very accurate for rivers equiped with an artificial weir and rivers with little or no topographic change during floods. However, this method has limitations: (i) it is very expensive to maintain over time because it requires a lot of human resources and exposes individuals to significant risks in case of gauging during floods, (ii) it is difficult to expand the number of hydrometric stations of this type while scientific and societal demands are increasing, (iii) this method cannot be applied in rivers that are prone to frequent topographic changes.

To overcome these limitations, we are considering new methods of monitoring flow discharge in mountain rivers, more direct and with a minimum need of gaugings. These methods are based on non-contact instruments: fixed radars for water level and surface velocity (H-V radars) eventually coupled with a digital camera. All instruments are controlled by a unique datalogger (Nord et al., 2020). H-V radars measure typically every 10 min. Video sequences of 10 s are recorded every 30 min during floods by the camera. LSPIV (Large Scale Particle Image Velocimetry) analysis are performed for selected video sequences to derive surface velocity field, discharge measurement and average cross-sectional velocity.

We build a relationship between the local velocity measured by the fixed radar and the average cross-sectional velocity. This relation can be calibrated based on the « automatic » gaugings resulting from the LSPIV analyses when a camera is available. Alternatively the use of a theoretical model of velocity distribution within the cross-section (isovel method) enables us to predict this relation. The relationship between water level and the wetted area is established on bathymetric field surveys. The time series of discharge is obtained by multiplying the average cross-sectional velocity (from the radar velocity) by the wetted area. This approach has been developed progressively during previous master internships (Tafasca, 2017; Hasanyar, 2019; Safdar, 2021). It is time now to apply this method as a whole in different environments in order to calculate the associated uncertainties and determine its limits of applicability. Several velocimetric stations managed by the IGE in the Alps and the Cévenne-Vivarais region will serve as a basis for this work.

In parallel, we are currently working on the development of a new generation of smart instruments in the framework of the TERRA FORMA project. Concerning the monitoring of flow discharge, our work aims to develop a "low cost" hydrometric station, equiped with remote data transmission, easy to deploy in the field, and which integrates radar systems for water level and surface velocity. We have already selected and acquired a set of commercial and industrial radar sensors. Part of the internship work will be devoted to comparing these sensors in the laboratory channel and in the field. For the industrial sensors, tests with micro-controllers may be carried out in conjunction with the IGE's technical department, which is working on the control system of this "low-cost" hydrometric station.

Location of the internship: Institute of Environmental Geosciences (IGE)

Duration: 5 to 6 months from February 2023

Profile: student in Master 2 or engineering school

Required skills: computer programming (R, Python), metrology, instrumentation, interest in hydraulics and environmental sciences

Applications: CV, covering letter and M1 internship report to be sent by email to the supervisor.

References:

Hasanyar Masihullah : Estimation of flow discharge by non-contact measurements. Master 2, Hydraulics and Civil Engineering, G-INP, 2019.

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Safdar Suffiyan : Erosion and sediment transfer in a mesoscale catchment. Master 2, Urban - Atmosphere, Water and Environment, Ecole Centrale de Nantes, 2021.

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