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Development of a loosely coupled geomatic-hydrological modeling approach for flood inundation mapping in small watersheds

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In Québec, Canada, extraordinary spring conditions in 2017 and 2019 have provided major incentives for the provincial government to commission the updating of current flood inundation maps. Indeed, some of these maps, dating back as far as the 1980's, do not adequately reflect actual flood risks. Classical hydrodynamic models, such as HEC-RAS (1D, mixed, or full 2D), are generally used to perform the mapping, but they do require significant expertise, hydrometric data, and high-resolution bathymetric surveys. Given the need for updating flood inundation maps and reducing the associated financial costs (data collection and human resources), there is an emerging demand for simplified conceptual methods. In recent years, several models have been developed to fulfill this need, including the geomatic Height Above the Nearest Drainage (HAND) method which solely relies on a the digital elevation model (DEM).

This project aims at expanding upon earlier work carried out with HAND which was designed to compute the required water height to flood any DEM pixel of a watershed. The information provided by HAND along with the application of the Manning equation allow for the construction of a synthetic rating curve for any homogeneous river reach. This methodological approach has been used to come up with first-instance flood inundation mapping of large rivers in conterminous United States with a matching rate reaching 90% when compared to the use of HEC-RAS. However, to our knowledge, this has not been assessed for small rivers, and our goal here is to validate this simplified conceptual approach using two small watersheds (less than 200 km^2) in Quebec.

The results of this study show that the ensuing synthetic rating curves for small rivers are consistent with river hydraulics (Froude numbers meeting the subcritical flow requirement behind the use of Manning equation) and *in-situ* derived rating curves of six hydrometric stations. The results also demonstrate the relevance of this approach when comparing the use of HAND with HEC-RAS 2D for the hydrographic networks of the two watersheds given flows simulated by a semi-distributed hydrological model (i.e., HYDROTEL). For this demonstration, the forcing data include the precipitation and temperature time series of the Canadian precipitation analysis system. Preliminary results indicate good performances (hitting rate above 60%) for the pilot river watersheds which are located in a data-sparse region.

While the preliminary results illustrate the potential to produce first-instance flood inundation mapping solely based on a DEM and simulated streamflows, future work will contribute to the advancement of our understanding of flood risks in poorly-gauged watersheds. HAND-derived inundation mapping will be further analyzed and compared to HEC-RAS-2D applications (i.e., the diffusion-wave equations), although the presence of complex urban infrastructures such as culverts, pipes, or bridges may represent a major challenge for the proposed approach. We believe a modeling continuum based on hydrological modeling and HAND-derived flood inundation mapping will inform and strengthen land management planning and contribute to the elaboration of public safety protocols.