Redefining boundaries – A Nordic collaboration for streamlined and accessible catchment modeling

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INTRODUCTION

Imagine if developing fully functional hydrological catchment models would only require hours instead of several days.

What if you could efficiently undertake detailed catchment modeling even on projects with limited resources or accurately cover extensive areas? In current practices, building hydrological catchment models is very resource-intensive and a costly part of a project, which reduces the broader adoption of high-quality models. A typical model-building process can take up over 50% of the allocated project time, leaving very limited time for analyzing multiple scenarios and developing creative solutions.

Fluidit (Finland) and **SCALGO** (Denmark) have, in a collaboration project, taken up the task of improving and automating the stormwater model building process. The result is a novel catchment toolbox that encapsulates the power of massive data processing mastered by SCALGO. It seamlessly connects with modern best practice hydrological modeling methods by Fluidit, all integrated into intuitive user interfaces. The novel approach automatically defines catchments based on topography and stormwater inlet locations. In addition, the toolbox produces most hydrological catchment parameters for Stormwater Management Model (SWMM) method used by Fluidit.

A prototype of the Catchment Toolbox was tested on Fluidit's extensive combined sewer model prepared for the Helsinki Region Environmental Services Authority (HSY) in Finland. The method has proven to be very efficient in multiple test areas compared with other automated catchment definition procedures. **A master's thesis** [3] about the pilot project will be finalized by the end of 2022.

METHODS

A NOVEL CONCEPT CONNECTING THE TWO WORLDS TO CREATE A STREAMLINED PROCESS:

1) Massive data processing for catchment analysis and high-level studies.
2) Detailed hydrological and hydraulic modeling for planning and design.

An overview of the concept is shown in Figure 1. The process consists of three phases.

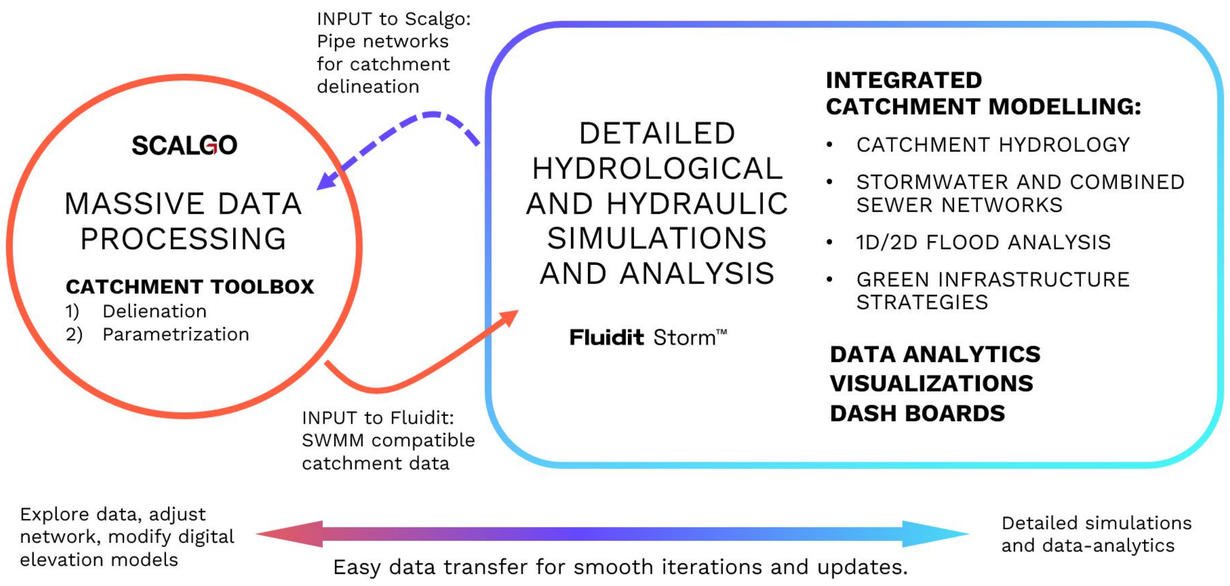

Figure 1 – Concept for connecting the massive data processing with detailed hydrological and hydraulic models (source: Fluidit Ltd)

PHASE #1 **CATCHMENT DELINEATION**

The catchment delineation tool automatically defines watersheds at various scales, not only based on the terrain model but also using the location of inlets into the stormwater network. The high-precision terrain models are pre-processed to allow continuous flow paths on the surface, for example, by considering culverts and bridges.

The tool allows the designer to adjust the tolerance and resolution of the catchment delineation process to best suit individual project requirements. For example, the user can instantly choose the minimum size for sub-catchments and observe its impacts on sub-catchment delineation. The output is a universally applicable GIS catchment file.

PHASE #2 **CATCHMENT PARAMETRIZATION**

The catchment parametrization tool automatically produces industry-standard SWMM-compatible catchment parameters. The parameters are derived based on terrain models and land-cover data, including:

- Area
- Land use coverage
- Imperviousness
- Average slope
- Longest flow path

PHASE #3 **INTEGRATION TO DETAILED STORMWATER MODELS**

The toolbox streamlines the transition from catchment data processing in SCALGO Live to detailed hydrological and hydraulic modeling in the Fluidit Storm modeling package. Conversely, Fluidit users can easily create and update catchment maps from the SCALGO Live platform.

RESULTS

EARLY RESULTS FROM THE PILOT PROJECT
The efficiency of the automatic catchment definition process in Catchment Toolbox is tested at a city scale in Helsinki, Finland, in a pilot study and master's thesis by Fluidit. The study compares the Catchment Toolbox method with other automated processes, such as QGIS, GIStoSWMM, and the current method used by the utility (HSY). Detailed analysis of hydrological and hydraulic impacts of using the different techniques will be available upon completing the master's thesis by the end of 2022.

The early results are encouraging. The Catchment Toolbox can quickly produce accurate catchment maps for hydrological modeling based on stormwater inlet locations and terrain models. The time needed for the definition process varies from a few seconds to a few minutes. In contrast, the other partially automated methods require hours of the modeler's time spent on complicated steps and often produce output at the wrong scale (e.g., too detailed) for meaningful hydrological modeling.

TIME-SAVING AND CONSISTENCY
The concept offers significant time-saving potential for model building, which benefits municipalities, water utilities, and consultancies. The benefits of including stormwater inlets, as opposed to using only topography to delineate catchments, are highlighted in flat urban areas where sub-catchments are highly dependent on the location of the underground pipe network. As users can freely choose the minimum size for catchments, they can create catchment maps for hydrological modeling at various scales with a few clicks.

SCALABILITY
The method will be fully scalable to all countries where the SCALGO platform is available. The output is suitable for all SWMM-based software packages. The Fluidit hydraulic modeling packages are available globally to achieve the most streamlined model building process with the Catchment Toolbox.

DISCUSSION

The data driven approach enables easy application of modern hydrological modeling and big datasets in the design of stormwater and combined sewer systems. By estimating most catchment parameters automatically, the Catchment Toolbox method can save a vast amount of time typically required for catchment parametrization.

The automated process also improves transparency and replicability of the hydrological modeling process as it reduces the manual catchment definition required. While users still need to validate the results provided by the catchment tool, automation helps to carry out the typically laborious tasks very efficiently.

Despite automatic procedures, the modeler must stay in control of the process. If necessary, the modeler can override the automatically computed estimates and specify parameters individually. The flexibility of the process is essential in stormwater models, where the designer's know-how and judgment are still crucial in model building and analysis.

CONCLUSIONS

The new Catchment Toolbox streamlines two well-known laborious tasks of stormwater modeling: catchment delineation and parametrization. The collaborative prototype developed by Fluidit and SCALGO provides a streamlined, fact-based, and consistent approach to building and simulating detailed hydrological and hydraulic stormwater models.

The method offers significant time-saving potential, which enables higher-quality stormwater, flood risk estimation, and associated climate adaptation planning projects with limited resources. There are no more excuses to overlook detailed hydrological modeling.

References:
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