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The Fresnel Platform, increasing the Greater Paris Urban Resilience

La Plateforme Fresnel, au service de la Résilience Urbaine du Grand Paris

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RÉSUMÉ

Les pluies intenses locales ont de grandes conséquences dans les zones urbaines et, sous la menace du changement climatique, elles frapperont nos villes encore plus durement et fréquemment. Comprendre leurs impacts est crucial pour les systèmes de gestion de l'eau et éviter les inondations. C'est l'objectif de l'observatoire hydrométéorologique urbain avancé, la plateforme Fresnel du *Co-Innovation Lab* de l'ENPC. Cette présentation présente la plateforme SaaS Fresnel (*Software as a Service*) associée comme un exemple d'outils informatiques interactif pour améliorer dynamiquement la résilience urbaine du Grand Paris.

Elle offre un accès facile à divers produits basés sur les mesures de précipitation effectuées par le radar polarimétrique à bande X de l'ENPC à l'échelle du pixel de 125m. La plateforme diffuse ces mesures en accès libre et en temps réel, que ce soit pour le grand public ou pour les professionnels. Elle donne également accès aux données de pluies archivées du radar, pour des analyses spatiales et temporelles à plusieurs échelles. Enfin, elle fournit désormais une interface graphique à Multi-Hydro, un modèle hydrologique interne entièrement distribué et basé sur la physique, qui peut être configuré sur différents bassins versants sans étalonnage, en utilisant les données pluviométriques fournies par le radar en donnée d'entrée.

ABSTRACT

Local heavy rainfalls have strong consequences in urban areas, and under the threat of climate change they will hit our cities even harder and more frequently. Understanding their impacts is crucial for water management systems and avoid urban flooding. This is the purpose of an advanced urban hydro-meteorological observatory, the Fresnel platform of the ENPC Co-Innovation Lab. This presentation discusses the associated Fresnel SaaS (*Software as a Service*) platform as an example of nowadays IT tools to dynamically enhance urban resilience of the greater Paris area.

It provides an easy access to various products based on precipitation measurements performed by the ENPC polarimetric X-band radar at the pixel scale of 125m. It broadcasts these measurements in free access and in real-time, whether for the general public or for professionals. It also provides access to archived rainfall data from the radar, for multiscale spatial and temporal analysis. And finally, it now provides a graphical interface to Multi-Hydro, an in-house fully distributed and physically-based hydrological model, which can be set up on different catchment without calibration, using the rainfall data provided by the radar as input.

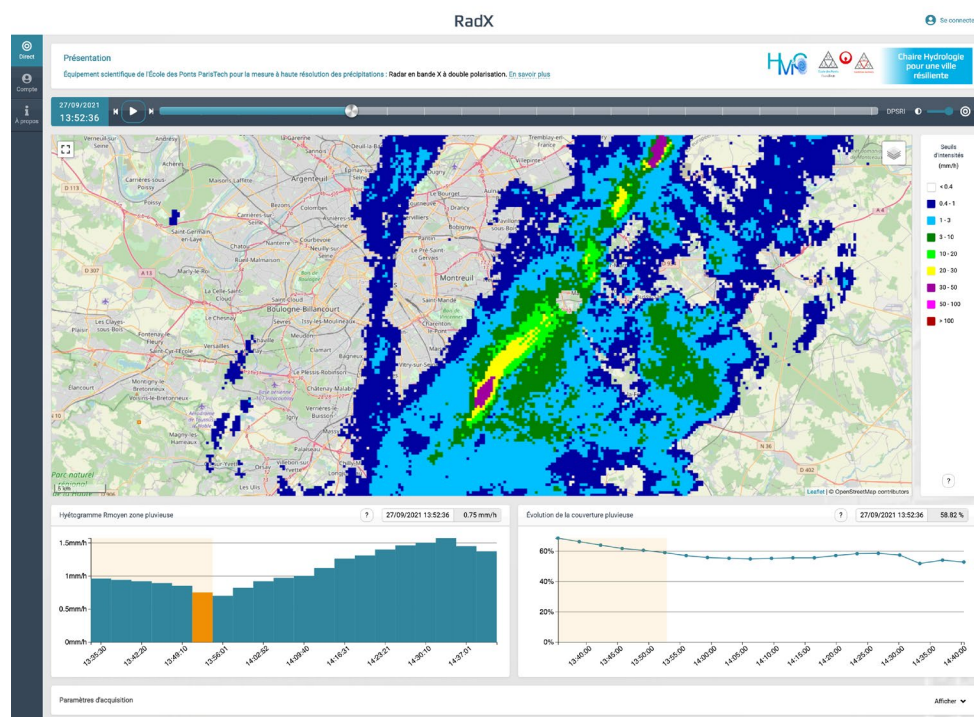
MOTS CLÉS

hydrologie, multi-échelle, résilience, simulation déterministe, Software as a Service (SaaS)

1 RADX

The polarimetric X-band radar at the ENPC's campus (East of Paris) introduced a paradigm change in the prospects of environmental monitoring in Ile-de France. The radar has been operating since May 2015 and has several characteristics that makes it of central importance for the environmental monitoring of the region (Paz, 2018). In particular, it demonstrated the crucial importance to have high resolution 3D+1 data, whereas earlier remote sensing developments have been mostly focused on vertical measurements.

Based on the radar data and other scientific measurement tools, the web platform for greater Paris was developed in participative co-creation, and in scientific collaboration with the world leader industrial in water management. As the need for data accessibility, a fast and reliable infrastructure was a major requirement from the scientific community, the platform was built as a cloud-based solution. It provides scientific weather specialists, as well as water manager, a fast and steady platform accessible from their web browser on desktop and mobile displays.



A screenshot from the RadX website, displaying live rainfall data on the upper part, and dynamic hyetogram and rain coverage graphics on the lower part.

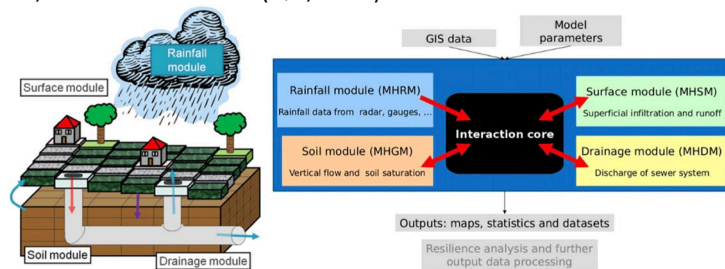
It displays real time rainfall data from the X-band radar, but also meteorological data from the Taranis Observatory such as temperature, air pressure, humidity... But it also enables the replay of user defined rainfall events from a calendar, allowing multi-scale analysis. Spatial analysis is possible from a square of 125x125m up to the full catchment, and temporal analysis from a few minutes up to a few days. Developments were made from user feedbacks, and some features such as the possibility for users to save their temporal and spatial selection for future re-use.

The components that make up this platform are designed to be configurable for specific case studies using an adjustable visual interface. Depending on a case study, specific components can be integrated to meet particular needs using maps, other visual tools and forecasting systems.

2 MULTI-HYDRO

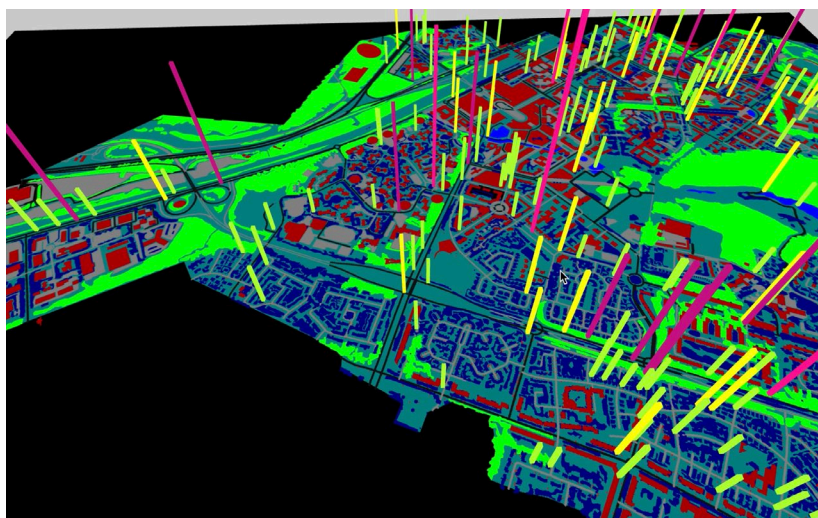
In the complex goal of increasing urban resilience, it is necessary to take into account the different technical solution of the water cycle in an urban environment at different scales. These concerns have helped define the development of Multi-Hydro: interacting models already proven to represent different components of the water cycle to allow substantial progress in the modelling of urban water combined with ease use. Multi-Hydro is a fully distributed rainfall-runoff model, based on physical equations supported by distributed and coupled models which has been developed by HM&Co Lab at ENPC (El Tabach et al., 2009; Giangola-Murzyn, 2013; Ichiba et al., 2018). It has already been successfully implemented and validated in several catchments (e.g. Ichiba et al., 2018; Gires et al., 2017, 2018; Versini et al., 2018; Paz et al., 2019).

It is based on an interaction core that utilizes four open source modules representing the water cycle (surface module, rainfall module, drainage module, and infiltration module). To account for the resilience, others modules have been added, like a nature based solution: green roof module to study the benefits of these infrastructures (Versini, 2018). But also other resilience structures like rain garden, green roof, bioretention swale, porous pavement, and rainwater tank (Qiu, 2021).



The Multi-Hydro model is based on an interacting core between four modules. Each of them represents a portion of the water cycle in an urban environment.

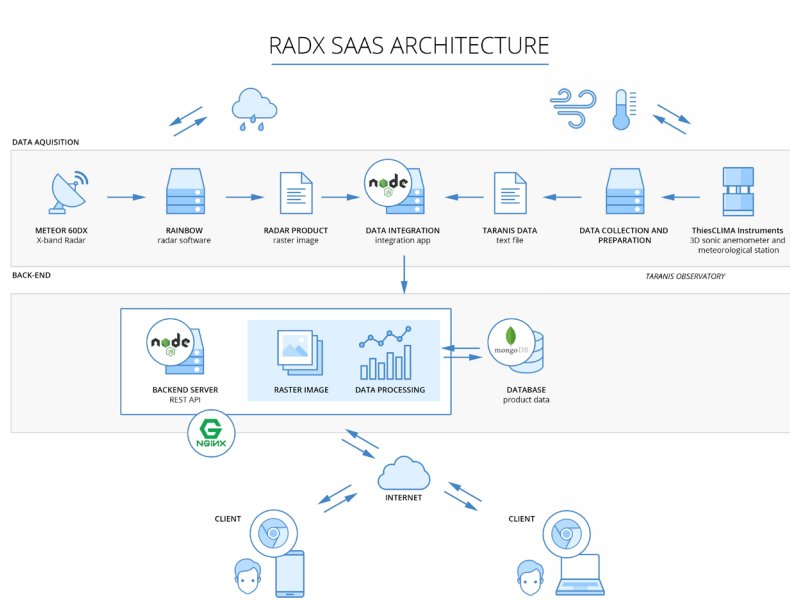
The implementation of a user interface for Multi-Hydro directly from a web interface, creates an interactive and easy to use, simulating tool for assessing hydrological responses from user defined parameters. Indeed directly from the Radx web interface, users can set up different scenarios on a given catchment, for example, modify some land use parameters to study the impact of nature based solutions on the discharge in the drainage system... The dynamic interface and the use of 3D library (Three.js), that includes a WebGL renderer, gives the user an intuitive and efficient way to spot singular points of the output display.



3D interactive render of the infiltration output from multi-hydro simulation, using the Guyancourt catchment. The height of each voxel is proportional to its value, their color codes indicate passed threshold values. The base map is the land use with

colors for each land use.

3 TECHNICAL IMPLEMENTATION



RadX SaaS architecture, a complete integration chain

The RadX SaaS was built to be able to deal with "big data" (Kleppmann, 2017) from different high precision sensors, it uses a complete data integration chain. To sum up briefly:

- The X-band radar generates different radar products
- The Taranis observatory generates meteorological data
- The data are stored in MongoDB, a NoSQL database (Bradshaw, 2019),
- Then a back-end provides an API to the front-end to display the requested rainfall data to the user.

The RadX application has been developed using the micro-services architecture (Newman, 2021). It is built using different components that are loosely coupled, in opposite to a monolithic application. It allows to easily work on different services separately and implement new ones with ease, even for third party without having to rewrite previous code. This architecture grants us to be language agnostic and as such, different programming language are used depending on their best use cases, for instance the user interface and the server side are written in JavaScript, many services are written in python using dedicated library like GDAL for geospatial treatment, and also written in Scilab like Multi-Hydro.

4 CONCLUSION

The Fresnel SaaS provides a complete integrated chain of data from high precision sensors. It enables the display of real time radar data and archived data. Coupled with the fully distributed deterministic simulation tool : Multi-Hydro, it becomes a fully operational tool for urban planners to study on a multi-scale approach, and provide ways to improve the urban resilience, with nature based solutions for instance. The platform is still in development with close contacts and feedbacks from the scientific and professional world.

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