# Hydroweb: an Open Source educational WebGIS platform for the understanding of spatio-temporal variations of meteorological parameters at the watershed scale

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### Introduction

GIS is an interdisciplinary technology able to support high-level thinking and spatial reasoning. It allows students to visualize complex real world problems, and supports multiple modes of learning [1]. But GIS remain unused at the primary school level. Indeed, there is a gap between a declared interest in

GIS technology and their effective slow rate of implementation in classrooms [2]. The complexities of desktop GIS are possible brakes on their adoption in schools. They can be cut by using web-based GIS solutions. Indeed, internet-based mapping provides an invaluable way for establishing GIS technology in the primary and secondary education ("K-12 education community" in USA and Canada), while avoiding the main barriers associated with desktop GIS. Such tools can support standard methods of teaching and learning while providing basic analysis tools for studying and exploring geographic or other scientific data in the classroom [3]. This kind of platform is ideal for many teachers and 12-14 years old children that are not able to spend the time and energy required to run desktop GIS ([4], [5]).

Bodzin and Anastasio [6] have identified several internet-mapping solutions dedicated to earth and environmental systems education. Focusing on watershed science, a very interesting Web-based GIS tool was developed as part of a teacher training project in the State of Michigan that focused on Comparing and Contrasting the physical aspects and human use of Watersheds In Michigan (CCWIM, [1]). On this basis, a Web-based GIS application named the H20Mapper was developed to provide an online map-based environment for storing data on water quality, terrain, and land use for different watersheds in Michigan (http://h2omapper.resa.net/pmapper/map.phtml). The use of the platform was included in a specific program developed by the Michigan Department of Environmental Quality (DEQ) to help schools integrate specific economic and environmental materials into their science and social studies curriculum consisting of five foundation environmental education concepts: ecosystems and biodiversity, land use, water quality, energy resources, and air quality.

Given the substantial and growing need for materials development in the areas of environmental science and spatial thinking [7], we developed Hydroweb, an educational WebGIS platform for the understanding of spatio-temporal variations of meteorological parameters at the watershed scale dedicated to primary and secondary education in Switzerland (http://lasigpc28.epfl.ch/hydroweb/). This platform is part of a Swiss environmental education program named "CCES@School" conducted by the Competence Center Environment Sustainability (CCES) of the ETH domain, the union of Swiss Federal universities and research institutions (http://www.cces.ethz.ch). CCES establishes a new thinking and priority setting based on sound scientific and engineering knowledge to integrate the principles of sustainable development into country policies and programs. One of its missions in particular is to achieve excellence in education and research and to focus research on crucial themes, ranging from climate and environmental changes to food safety, sustainable land use, natural resources and the management of natural risks.

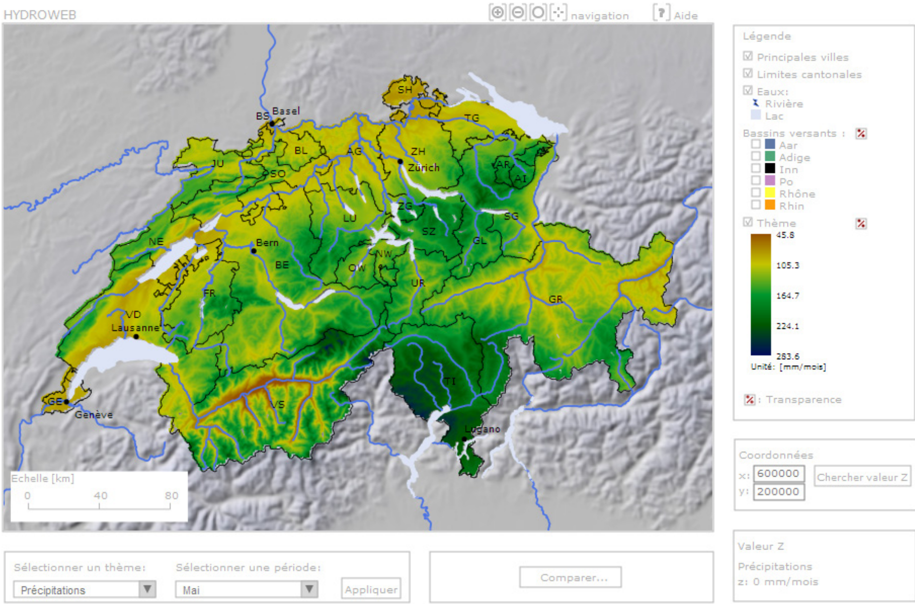
The project's main objective is to make Swiss students (12 to 14 years old children) aware of the spatial and temporal variations of environmental parameters at the watershed scale. It is also to make them understand the influence of the latter on the water balance as the result of the combination of several complex dynamic processes in which meteorological, soil, topography and anthropogenic factors are involved. Hydroweb also focuses on river discharge, a concrete impact of the water balance visible in the landscape. Finally, Hydroweb aims to stimulate the curiosity of children towards the functioning of their natural environment. Based on pedagogical concepts (inquiry-based and student-led investigations, open-ended questions, and real world experiences learning environment), Hydroweb is made of two main complementary modules.

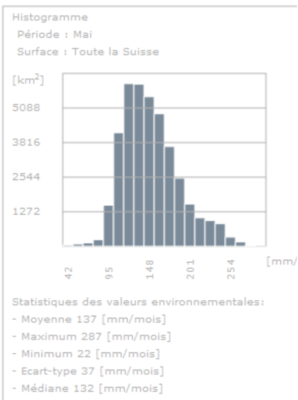
## WebGIS platform and data

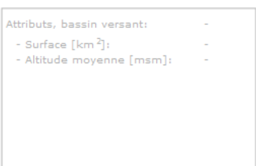
The Hydroweb project was conducted by a consortium constituted of two laboratories of the Ecole Polytechnique Federale de Lausanne (EPFL) and of the Educational Science University of Bern (PHBern). Laboratories of Environmental Fluid Mechanics and Hydrology (EFLUM) and of Geographic Information Systems (LASIG) have developed the technical content of the WebGIS platform while the Educational Science University of Bern has elaborated the educational part of the project [8].

The WebGIS platform uses environmental information layers (see Figure 1). This tool is easy-to-use and permits to visualize, compare, look for and analyze monthly, seasonal and yearly meteorological data (temperature, precipitation and evaporation). Online instructions explain how to use the WebGIS platform.

**FIGURE 1**




The data constituting GIS layers (topography, state borders, watershed limits and hydrographic network) have been produced by swisstopo (www.swisstopo.ch). Meteorological data were recorded by a network of ground-based automatic weather stations operated by MeteoSwiss (http://www.meteosuisse.ch). A mean of Temperature, precipitation and evaporation values between 1961 and 1990 was calculated, generalized and made available in raster layers whose spatial resolution is 25 meters.

The challenge in the development of Hydroweb was to find an architecture that could easily be migrated to other servers in order to be used within an educational institutions server infrastructure. This implied that we had to ignore map-engines such as MapServer, webservices such as WMTS and complex database engines and structures. We therefore chose to base Hydroweb on the open standard SVG both for the interface and map-rendering and javascript for making the system dynamic. These standards are natively supported in major browsers. The available layers are either stored in raster-images or, if vector-based, in SVG-shapes. Through the use of javascript, layers are dynamically loaded into the browser's memory. One further challenge was the display of map-related values in the interface (e.g. when the user moves his pointing device over the map). This functionality was implemented through the generation of value-matrices that are dynamically loaded at the same time a layer is loaded. Javascript dynamically interpolates values corresponding to both, the pointing device's screen coordinates and the layer and displays the calculated values in the system's interface.

Some parts of the SVG interface are dynamically generated by PhP (e.g. when the interface's language is changed). Therefore whole the system only needs a simple webserver and PhP as a minimum installation to run. For the pre-calculation of the value-matrices and histograms the well-known PostgreSQL/PostGIS database system was used.

## Pedagogic notebook

A pedagogical notebook proposing applied educational activities grouped according to a) the variation of environmental parameters (temperature, precipitation and evaporation) and b) hydrological processes (river discharge, rain regime, watershed analysis). The exercises are based on the use of the WebGIS system and the students have to answer different questions (e.g. identify the geographical coordinates a specific location using a topographic map, extract precipitation and temperature data with Hydroweb, and create a seasonal climatogram for this place with the help of a spreadsheet). The different manipulations permit to develop specific competences like graph elaboration, measure reporting, data analysis, discussion and thinking about a given topic, etc. The notebook constitutes an initiation to scientific investigations; it proposes a questioning phase, the formulation of work hypotheses, the analysis of data and the discussion of results obtained. All activities are independent. Some of them can spread over several months and other are punctual. All activities can be enriched, modified, or completed according to the scholar level, and adapted to specific objectives to be reached and to teaching conditions.

## Conclusion

The Hydroweb platform allows students to manipulate georeferenced meteorological data through a very simple WebGIS interface, and to understand their geographical distribution during the different months or seasons in the various watersheds of the Swiss territory. Its architecture is based on open source GIS components and can easily be migrated to other servers in order to be used within any educational institution server infrastructure. Coupled with a teaching guide that includes thematic activities, Hydroweb is an open-ended and inquiry-based learning environment allowing pupils to lead their own investigations. It has direct correlation to real world experience, enables the visualization of complex real world problems, and supports multiple modes of learning.

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