International Conference on Hydroinformatics

2014

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11th International Conference on Hydroinformatics
HIC 2014, New York City, USA

RWater –A CYBER-ENABLED DATA-DRIVEN TOOL FOR HYDROLOGY EDUCATION

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The objective of this paper is to demonstrate a new web-based tool RWater, in which a graphical user-interface enables students to understand various cause-and-effect relationships in natural water cycle. The appropriateness of this tool for a classroom environment lies in its features that (i) it is accessible from any remote computing device having an internet browser, (ii) it does not require installation of any software, (iii) it does not store any data locally and (iv) no prior programming skills are needed. By using real-time hydrologic data-driven modules, students can write small programs within RWater's interface. Students can use their scripts in R to create visualizations to identify effect of rainfall distribution and landuse type on streamflow, seasonal characteristics of hydrologic cycle, as well as the climate change impacts on flow pattern. The overall experience from this tool can potentially improve students' analytical ability of interpreting complex hydrologic processes in a classroom environment.

BACKGROUND

Hydrology is conventionally taught in a classroom, using the physical laws of mass, momentum and energy. As a result, students have difficulty developing a conceptual outlook, intuitive understanding and self-learning skills about these physical scientific processes based solely on mathematical theories in classroom lectures. Computer-based hydrologic simulation models can play as a supplement [1-3] providing students a user-friendly environment for testing various hydrologic scenarios such as land-change effects and flooding impacts with different storm cases. A popular resource is the US Army Corps of Engineers' Hydraulic Engineering Center's (USACE-HEC) modeling toolset (http://www.hec.usace.army.mil/); especially HEC-RAS and HEC-HMS and their GIS-enabled versions have motivated the development of a number of hydrology curriculum modules (look into http://web.ics.purdue.edu/~vmerwade/tutorial.html). The HEC's modeling systems have reached a nearly universal exposure as a common toolset in hydrology courses. However, computer models can be conceptually and computationally challenging to be utilized in the undergraduate classroom and is currently most used in graduate contexts [4]. As an aid to this situation, there have been multiple efforts to create open-source, interactive modeling and visualization curriculum focusing hydro-meteorology and its descriptive statistics. Among the noteworthy, MIT's StarHydro modeling platform (http://web.mit.edu/star/hydro/index.html), the Teaching Quantitative Skills in the Geosciences website (http://serc.carleton.edu/quantskills/index.html), Community Surface Dynamics Modeling System (CSDMS, http://csdms.colorado.edu/wiki/Hydrological_Models), COMET (http://www.comet.ucar.edu) and HydroViz (http://hydroviz.cilat.org/hydro/) are getting applied in many hydrology curricula. Nevertheless, the overall functionality, input-output visualization in almost all these tools require a certain level of understanding and conceptualization from a student as well from an educator's perspective. As a result, the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) urges development of simpler yet illustrative toolsets for easier and productive dissemination of hydrology education. From this perspective, a new web-based, real time hydro-meteorological data-driven educational tool, called RWater, is launched using Purdue University's HUBzero technology. The newly designed tool can potentially merge the lack of an effective educational toolkit for learning the cause-and-effect relationships in hydrologic cycle at high school level, also being fully suitable for undergraduate and graduate classes. This paper describes some of its potential functionalities as well as its future application strategies.

RWater INTERFACE AND INSTRUCTIONAL METHODOLOGIES

The RWater tool is available at https://drinet.hubzero.org/resources/rwater/; any user having a valid email address can create an account and access the tool. It can be used from a remote computing device having a standard internet browser, without prior installation of any software. The interface (see Figure 1) is built on RStudio (https://www.rstudio.com/). Moreover, it does not have any computational or data storage requirement. The basic design theme for this tool consists of the following:

(i) Students will learn to analyze hydro-climatic scenarios, starting from extraction of real time field data (streamflow, rainfall, temperature etc.) and creation of different visualizations.

(ii) Being guided by the instruction modules in RWater, students will write their own R program to create visualizations. Therefore, working in RWater will aid developing simple computer programming skills which the students can further replicate in various applications in future.

To facilitate usage of RWater in classrooms, a total of 8 learning modules are embedded into the interface. The modules ranged from basic activities (e.g., disseminating concepts of hydrologic cycle and watershed characteristics) to advanced analysis of field data. Each module contains relevant definitions, instructions on data extraction and coding, as well as the technical questions based on the possible visualizations which the students would create. Thus, the current version of RWater's interface houses three items together in the same working screen: (i) the coding workspace, (ii) visualization window, and (iii) instruction modules, providing a self-contained learning environment the students can work with from any location and/or device. The following is a brief description of these modules:

Module 1: Brief classroom dissemination of nature's hydrologic cycle and its components;

Module 2: Getting familiar with concepts of watershed, stream network, landuse and climate change;

Module 3: (a) Downloading rainfall-temperature data for an NCDC gage station; (b) loading the data into RWater, creating rainfall hyetographs and temperature time-series for that particular location;

Module 4: (a) Downloading streamflow records for a USGS monitoring station; (b) loading the data into RWater, creating streamflow hydrographs for that particular location (see Figure 1 for example);

Module 5: (a) Analyzing the effect of rainfall distribution on streamflow using real time data, (b) understanding flow peaks, lag time and their physical significance;

Module 6: (a) Understanding the role of landuse (urban/rural) on streamflow pattern under a similar hypothetical rainfall event, (b) split-sample analysis of long term flow records to identify ongoing landuse change at any particular geographic area;

Module 7: Using long-term weather data for calculating climate change attributes;

Module 8: Flood Frequency Analysis to understand combined effect of landuse and climatic change.

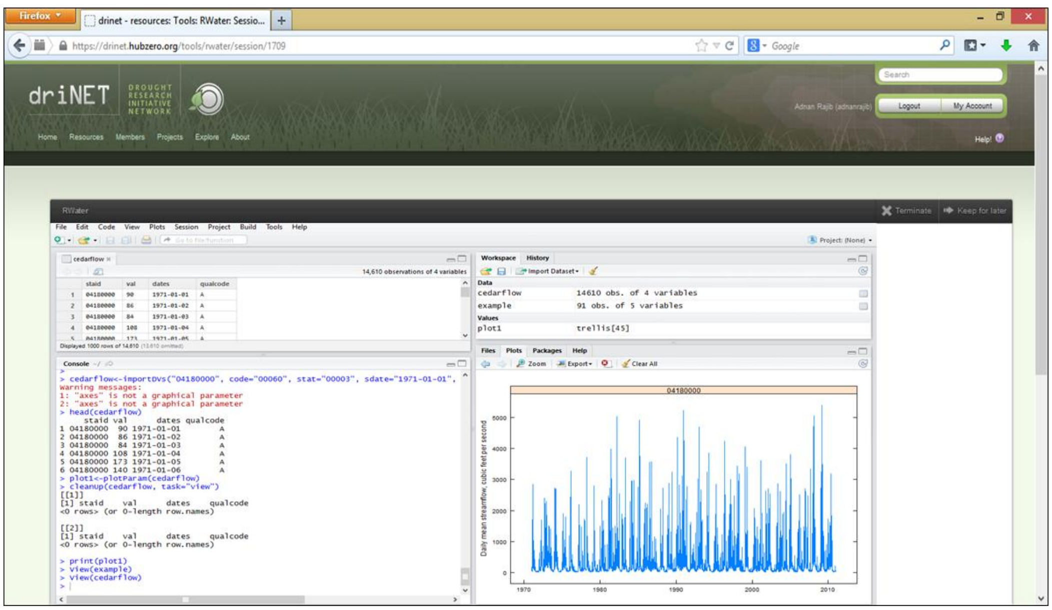

Figure 1. RWater interface in https://drinet.hubzero.org/resources/rwater/. The plot in the figure shows an example of directly extracting USGS stremflow data for a particular monitoring station and creating the hydrograph by writing a simple R code within the interface.

FUTURE IMPLEMENTATION

In order to assess its suitability in real time classroom atmosphere and to evaluate learners' perception over its utility, the current version of RWater will be tested in a three-phase aspect: (i) for high school students in a limited training program, (ii) for high school teachers in a workshop mode, (iii) in undergraduate hydrology courses. RWater has already been offered as part of a course called 'Hi-tech Hydrology' in the College of Education of Purdue University. The course is designed for 9th to 12th grade high school students in the summer residential study program of the Gifted Education Resource Institute [5]. The tool and the instruction modules will be applied covering total 10 3-hour class sessions starting from 30 June to 12 July 2014. The next phases of testing on this tool will be designed accordingly based on the feedback from the high school students.

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