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Better understanding of hydrologic process through data-driven learning facilitated by collaborative open web-based platforms

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Abstract

The era of "big data" promises to provide new hydrologic insights, and open web-based platforms are being developed and adopted by the hydrologic science community to harness these datasets and data services. This shift accompanies advances in hydrology education and the growth of web-based hydrology learning modules, but their capacity to utilize emerging open platforms and data services to enhance student learning through data-driven activities remains largely untapped. Given that generic equations may not easily translate into local or regional solutions, teaching students to explore how well models or equations work in particular settings or to answer specific problems using real data is essential. This paper introduces an open web-based learning module developed to advance data-driven hydrologic process learning, targeting upper level undergraduate and early graduate students in hydrology and engineering. The module was developed and deployed on the HydroLearn open educational platform, which provides a formal pedagogical structure for developing effective problem-based learning activities. We found that data-driven learning activities utilizing collaborative open web platforms like HydroShare and CUAHSI JupyterHub computational notebooks allowed students to access and work with datasets for systems of personal interest and promoted critical evaluation of results and assumptions. Initial student feedback was generally positive, but also highlights challenges including trouble-shooting and future-proofing difficulties and some resistance to open-source software and programming. Opportunities to further enhance hydrology learning include better articulating the myriad benefits of open web platforms upfront, incorporating additional user-support tools, and focusing methods and questions on implementing and adapting notebooks to explore fundamental processes rather than tools and syntax. The profound shift in the field of hydrology toward big data, open data services and reproducible research practices requires hydrology instructors to rethink traditional content delivery and focus instruction on harnessing these datasets and practices in the preparation of future hydrologists and engineers.

Hosted file

`HydroLearn manuscript_2021.pdf` available at https://authorea.com/users/387348/articles/514898-better-understanding-of-hydrologic-process-through-data-driven-learning-facilitated-by-collaborative-open-web-based-platforms

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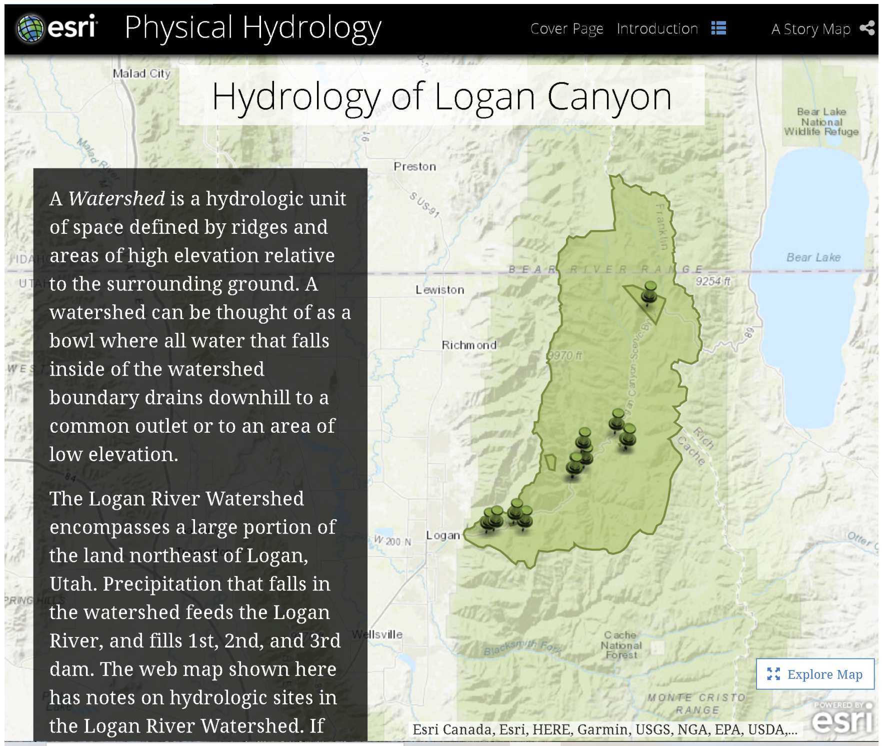
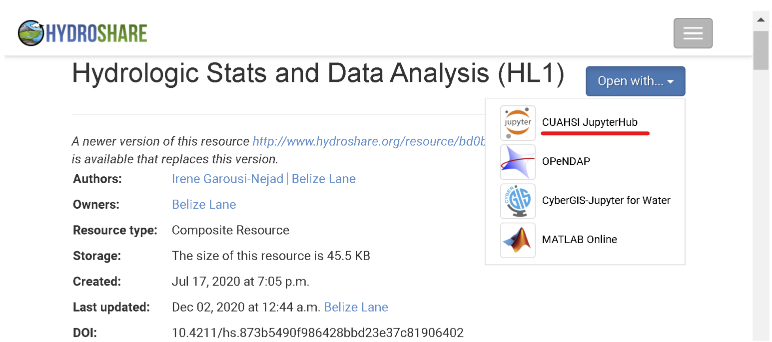


For this exercise, we will use the HydroShare Jupyter Notebook environment. The notebook is created within this resource, which is accessed using your HydoShare login information. You will need to create a HydroShare account at HydroShare if you haven't already. You can scroll down and read the abstract. To use Jupyter Notebook for this assignment, you need to click on the **Open with** on the top right of the resource. Select **CUAHSI JupyterHub** and for Server Options select "**R [version] Scientific**."

Note that you will need to become a member of the **CUAHSI JupyterHub** group to use this free service. This account must be approved, so setting this up *ahead of time* is recommended.

It is recommended that you open the Notebook from this page in a new window and then continue with HydroLearn for guidance on how to work through the notebook. That is best done with the HydroLearn instructions and the Jupyter Notebook open side-by-side.



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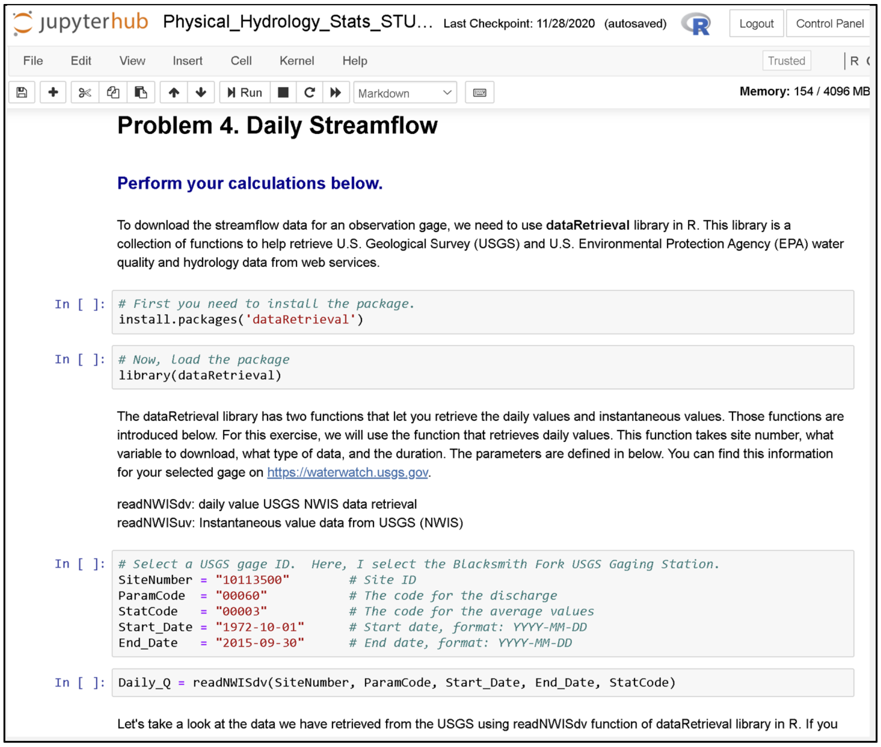
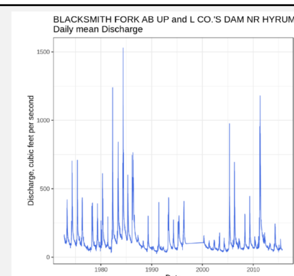
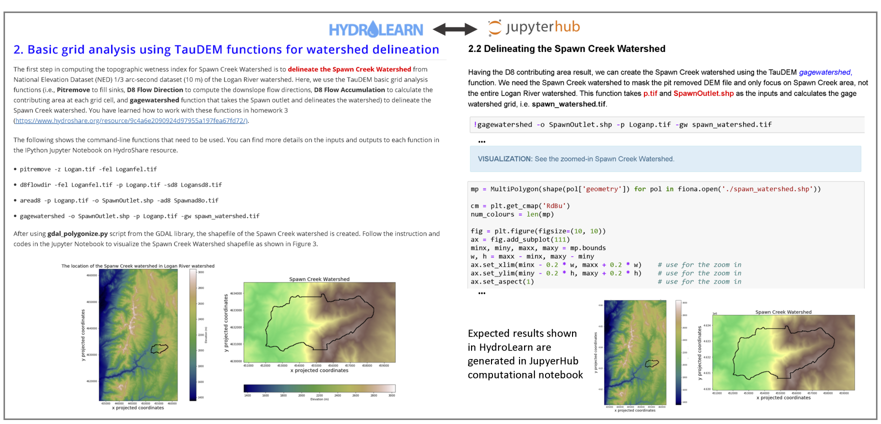


Student Response to Question 4:
The plot shows daily mean discharge observed at the Blacksmith Fork USGS gage over 43 years (1972-2015). The minimum and maximum values are 26 and 1530 ft3/s. The data was retrieved using dataRetrieval in R.





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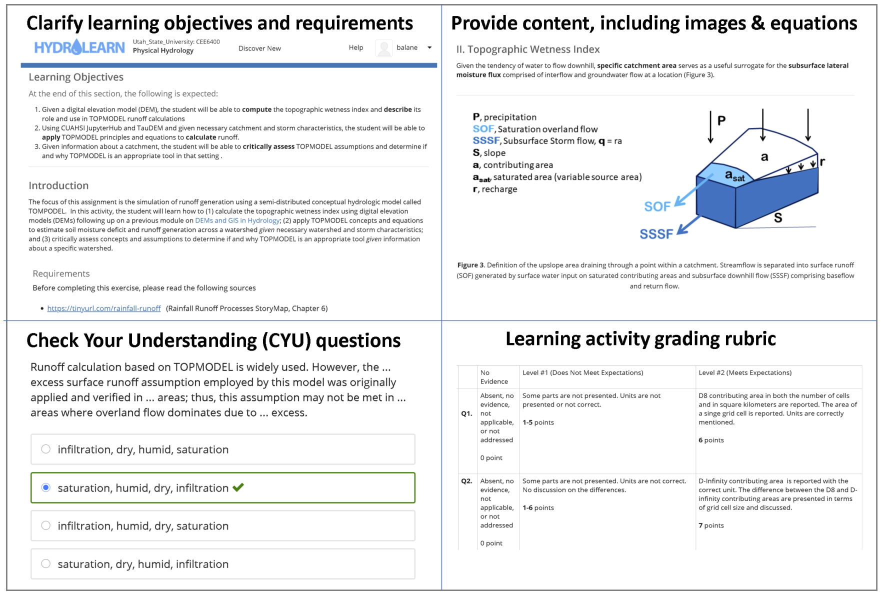

Module Section	Learning Objectives (The student will be able to...)	Learning Activities	Open web-based platforms and datasets
(1) Data Analysis and Statistics	Calculate water storage, fluxes, and uncertainty in components of the hydrologic cycle	Problems: Water balance, uncertainty	ESRI Story Map- Introduction to Physical Hydrology
	Navigate public websites to extract key hydrologic information	Problems: streamflow time series analysis	StreamStats; USGS NWIS
	Perform basic hydrologic data analysis for a watershed of interest	Authentic Task: For user-selected stream gage: (i) describe watershed attributes, (ii) retrieve streamflow data, (iii) perform statistical analyses including daily and seasonal plots, flow duration curve, exceedance, etc.	JH Notebook (R), including packages: DataRetrieval, zoo, ggplot
	Assess and interpret hydrologic trends in the context of a specific watershed	CYU: Multiple Choice and Open Response	
(2) Geographical Information Systems	Derive hydrologically useful information from digital elevation models (DEMs)	Problems, CYU: Open Response	USGS National Elevation Dataset
	Describe the sequence of steps involved in mapping stream networks, catchments, and watersheds from DEMs	Problems: Basic terrain analysis for hydrologic research	JH Notebook (Python), including packages: TauDEM, gdal, geopandas, rasterio, rasterstats
	Compute an approximate water balance for a watershed using open data	Problems: Water Balance, Runoff Ratio	
(3) Runoff Generation	Use appropriate terms to describe the processes involved in runoff generation	CYU: Concepts and definitions of runoff generation mechanisms	ESRI Story Map- Rainfall-Runoff Processes
	Differentiate between runoff generation mechanism and when and where each is likely to occur	Problems: Multiple Choice	
	Justify why and how specific changes in physical and climate attributes will influence dominant runoff mechanism and storm hydrograph shape	CYU: Open Response	
(6) Calculating Runoff using TOPMODEL	Compute the topographic wetness index and describe its role and use in runoff calculations, given a watershed DEM	CYU: Topographic wetness index, variable source area, hydrologic models	ESRI Story Map- Rainfall-Runoff Processes
	Apply TOPMODEL principles and equations to calculate runoff using CUAHSI JupyterHub and TauDEM and given necessary catchment and storm characteristics	Authentic Learning Activity: Simulate runoff using semi-distributed hydrologic model	JH Notebook (Python); ESRI Story Map - Rainfall-Runoff Processes
	Critically assess assumptions and determine if and why an appropriate tool, given information about specific catchment and storm attributes	Authentic Learning Activity: Estimate runoff across a watershed	