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Stream Discharge Module

This module was initially developed by Bader, N.E., T. Meixner, C.A. Gibson, C.M. O'Reilly, and D.N. Castendyk. 26 June 2015. Project EDDIE: Stream Discharge. Project EDDIE Module 5, Version 2. http://cemast.illinoisstate.edu/data-for-students/modules/stream-discharge.shtml Module development was supported by NSF DEB 1245707.

Summary

Stream discharge is a fundamental measure of water supply in stream systems. Low discharge may cause problems with water supply and fish passage, while high discharge may mean flooding. In this module, students explore real-time stream discharge data available from the United States Geologic Survey. Students use this data to assess changes in discharge with time, calculate flood frequency, and see the effects of urbanization and flood control. Project EDDIE modules are designed with an A-B-C structure to make them flexible and adaptable to a range of student levels and course structures.

Learning Goals

- Students will download, organize and analyze streamflow data.
- Students will use data to compare short-term and long-term discharge variability, and quantify climate change impacts on water quantity in their region.
- Students will calculate flood frequency from peak discharge data, and will calculate the effects of urbanization and flood control on flood frequency.
- Students will develop an understanding of the following scientific concepts:
    - Stream discharge
    - Variability and trends in time series data
    - Peak flow and flood events
    - Flood probability and recurrence interval
    - Effects of urbanization on discharge events
- Students will develop an understanding of the following statistical concepts:
    - Detecting variation and trends on short and long timescales
    - R-squared
    - Peak event probability

USGS employees installing a temporary stream gage near 13th Ave. and J Street, Cedar Rapids, IA (Photograph by Don Becker, USGS)

Context for Use

This module has been used in courses in introductory geology, environmental geology, and surface water hydrology. However, we believe the module could be successful in many courses. Instructors should look over the material to decide how to best tailor these activities to their courses.

Description and Teaching Materials

How to use this module:

This is probably too much material to cover in a three-hour lab period. You will need to select components of the modules based on your interests and the skill level of your students. For example, an introductory course may do a quick lab with just A and B, whereas an upper-level course might skip A and go straight to B and C. It is also possible to do different activities on different days, or to assign some components as homework.

We have set aside some data for Activities A and B so that you could run the activities if you lost network access for some reason. However, we intend for the instructor and students to access up-to-date data directly from the websites,, especially because this allows the students to explore and incorporate their own sites independently. Some parts of the activities are impossible without access to this online data.

Quick overview of the activities in this module

- *Activity A*: Introduction to variability in real stream data, using data from the USGS Hydrologic Benchmark Network
- *Activity B*: Identifying changes in discharge over time, using data from the USGS Hydrologic Benchmark Network
- *Activity C*: Calculating flood frequency from peak discharge data, and assessing the effects of urbanization and flood control on flood frequency, using data from the USGS real-time streamflow network

Workflow for this module:

1. Select and assign readings prior to the day of the activity.
2. Introduce the activity using the included Powerpoint and the notes below. Make sure that the importance of stream discharge comes across.
3. Give the students the handout.
4. Students explore the USGS Hydrologic Benchmark Network (HBN) website and make some graphs as a way of thinking about variability (*Activity A*)

5. Either provide data to students or help students download data from the HBN website. Guide the students through the plotting of winter and summer data from the Neversink River in New York. In the second part, students will be repeating these steps for a location of their choice (*Activity B*).
6. Students use the larger USGS stream monitoring network to calculate flood probability and recurrence interval for the Mississippi River at St Louis *(Activity C*).
7. As a possible take-home assignment, or in class if time allows, students can use their skills to estimate their own flood risk (*Activity C*).

Teaching Materials:

- Stream Discharge: Instructor's Manual (Microsoft Word 2007 (.docx) 106kB Jan25 17)
- Stream Discharge: Instructor's PowerPoint (PowerPoint 2007 (.pptx) 15.8MB Jan25 17)
- Stream Discharge: Student Handout (Microsoft Word 2007 (.docx) 863kB Jan25 17)
- Stream Discharge: Student Dataset for Neversink River (Excel 2007 (.xlsx) 604kB Jan25 17)

Teaching Notes and Tips

See the Instructor's Manual (Microsoft Word 2007 (.docx) 106kB Jan25 17) and Instructor's PowerPoint (PowerPoint 2007 (.pptx) 15.8MB Jan25 17) for notes and tips for carrying out this exercise.

Assessment

In Activity A, students are introduced to variability in real stream data, using data from the USGS Hydrologic Benchmark Network.

In Activity B, students identify changes in discharge over time, using data from the USGS Hydrologic Benchmark Network.

In Activity C, students calculate flood frequency from peak discharge data, and assessing the effects of urbanization and flood control on flood frequency, using data from the USGS real-time streamflow network.

Notes, tips, and answers are provided in the following files:

- Stream Discharge: Instructor's Manual (Microsoft Word 2007 (.docx) 106kB Jan25 17)
- Stream Discharge: Instructor's PowerPoint (PowerPoint 2007 (.pptx) 15.8MB Jan25 17)

References and Resources

Potential pre-class readings

There are probably more resources here than you will want to assign; choose readings that will complement the activities you will use.

- National Hydrologic Benchmark Data Fact Sheet- Murdoch, P. S., McHale, M. R., Mast, M. A., & Clow, D. W. (2005). The US Geological Survey Hydrologic Benchmark Network: US Geological Survey Fact Sheet 2005–3135, 6 p. Also available at http://ny.water.usgs.gov/pubs/fs/fs20053135/. The HBN fact sheet is an introduction to the USGS network of relatively undisturbed sites that are intensively monitored. (*Activities A and B*)
- National Climate Assessment Report for your region of interest http://nca2014.globalchange.gov/ (NE US which goes with Neversink case example found at - http://nca2014.globalchange.gov/report/regions/northeast) The NCAR report is useful for thinking about how climate change will affect particular regions of the world (*Activity B*)
- Lins, H.F., and J.R. Slack. 1999. Streamflow trends in the United States. *Geophysical Research Letters*, 26 (2), 227-230. This is an optional reading, perhaps for the instructor. It discusses the results of a study that is similar to what the students will attempt in *Activity B*.
- Campbell, J.L., C.T. Driscoll, A. Pourmokhtarian, and K. Hayhoe. 2011. Streamflow responses to past and projected future changes in climate at the Hubbard Brook Experimental Forest, New Hampshire, United States, *Water Resour. Res*., 47, W02514, doi:10.1029/2010WR009438. This paper describes the results of a study of discharge through time in Hubbard Brook, similar to the *Activity B*.
- Holmes, R.R., Jr., and K. Dinicola. 2010.100-Year flood–it's all about chance: U.S. Geological Survey General Information Product 106, 1 p. This is an introduction to thinking about flood frequency and recurrence interval (*Activity C*). brochure: http://pubs.usgs.gov/gip/106/pdf/100-year-flood-handout-042610.pdf, one-page version: http://pubs.usgs.gov/gip/106/pdf/100-year-flood_041210web.pdf
- Konrad, C.P. 2003. Effects of urban development on floods. USGS Fact Sheet FS-076-03. This short reading describes the increase in flashiness associated with urbanization, as students will assess at the end of *Activity C*. http://pubs.usgs.gov/fs/fs07603/
- Baker, D.B., R.P. Richards, T.T. Loftus, and J.W. Kramer, 2004. A new flashiness index: Characteristics and applications to midwestern rivers and streams. *Journal of the American Water Resources Association* 40(2): 503-522. http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2004.tb01046.x/abstract. This paper is an optional extension to *Activity C* for advanced students. Students can calculate the Baker-Richards flashiness index for streams in the USGS network using Excel.