Hydrological Modeling Project: Impacts of climate change on the discharge of catchments

About this project

In this project you will use HBV to investigate the consequences of climate change on a particular catchment (provided by your instructor) by producing discharge projections. We expect that you spend about 10 hours on this project. A user friendly version of HBV called HBV Light (Seibert and Vis 2012) is available to download: https://www.geo.uzh.ch/en/units/h2k/Services/HBV-Model/HBV-Download.html

Catchment description

You will receive precipitation, temperature, discharge (PTQ.txt) and evapotranspiration time series (EVAP.txt) for a period spanning 10 years, for a particular catchment. In addition, you will receive the other files necessary to run HBV (see page 3 for full list). You will also receive an R script 'climatechange_project.R' to help you carry out the analysis listed below. Do not rename the files or change the folder structure, otherwise you might not be able to run HBV.

Use these time series to determine characteristics of your catchment and illustrate it with a plot showing the annual discharge cycle (use monthly mean discharge values).

Catchment calibration with HBV and simulation under present climate

Calibrate HBV with the method of your choice: manual calibration, Monte-Carlo calibration or using the genetic algorithm (GAP).

Run HBV with the observed time series and compare the annual cycle of the observed and simulated discharge. Comment on the differences.

Discharge projections

To simulate the effect of climate change, use the so-called delta approach to obtain time series for future precipitation and temperature (P_{fut} and T_{fut}, respectively) from the observed time series (P_{obs} and T_{obs}):

$T_{fut}=T_{obs} + \Delta_T$
$P_{fut}=P_{obs} \times \Delta_P$

Note that the delta factors are additive for temperature and multiplicative for precipitation. For an example of how delta factors are created, read Fischer et al. (2012), which discusses both temperature and precipitation delta factors for Switzerland. Apply these factors to the observed time series; the obtained future time series will have the same length as the observed one. Account for the seasonal changes of the delta factors by applying a different factor to each season and keeping that factor constant for the whole season. After these factors have been applied to your time series, save these values as a new PTQ.txt file (make sure to either rename the file or place it in a different folder so that you don't overwrite your old file). You will also need to recalculate the values for your T_mean.txt file. The hard work is already done once you've created your new PTQ file. You will need to extract the temperature from your new PTQ.txt file and calculate a new monthly temperature mean values and save it as a new T_mean.txt file. For the scope of this project, it can be assumed that evaporation will stay the same.

Now run HBV with your new PTQ.txt and T_mean.txt files (EVAP.txt can stay the same as before). Compare the obtained annual cycle with the previous one. Which changes do you observe? Relate them to hydrological processes.

Beyond the seasonal cycle

Choose three hydrological characteristics and compute their value using:

1. The measured discharge data
2. The simulated discharge data under present climate
3. The simulated discharge data under future climate

Examples of hydrological characteristics include: maximum yearly discharge, maximum yearly snowmelt induced discharge, number of days with a discharge lower (or higher) than the 10% (or 90%) quantile. Think of other ideas!! Discuss how well HBV simulates these parameters under present climate and discuss the changes in these characteristics due to the changed climate input series and explain the changes in relation to hydrological processes.

About the project evaluation:

Please refer to the: 'Encyclopedia_supplementary_material_evaluation_criteria.pdf'.

References

Fischer, A. M., A. P. Weigel, C. M. Buser, R. Knutti, H. R. Künsch, M. A. Liniger, C. Schär, and C. Appenzeller, 2012: Climate change projections for Switzerland based on a Bayesian multi-model approach. *Int. J. Climatol.*, **32**, 2348–2371, doi:10.1002/joc.3396.

Seibert, J., and M. J. P. Vis, 2012: Teaching hydrological modeling with a user-friendly catchment-runoff-model software package. *Hydrol. Earth Syst. Sci.*, **16**, 3315–3325, doi:10.5194/hess-16-3315-2012.

HBV files to be given to students:

1. PTQ.txt: *The PTQ-file contains time series of precipitation [mm/day], temperature [°C] and discharge [mm/day].*
2. T_Mean.txt: *The T_mean-file contains the long-term values of temperature [°C].*
3. EVAP.txt: *The EVAP-file contains values for the potential evaporation [mm/day].*
4. Parameter.xml: *The parameter-file specifies parameter values to be applied to the catchment.*
5. Clarea.xml: *The Clarea-file specifies how much area of the catchment is located at each elevation zone.*
6. Δ T and Δ P: *Delta factors to be applied to temperature and precipitation in order to generate future time series of temperature and precipitation.*
7. climatechange_project.R: *An R script which will help students to implement the delta approach, analyze HBV output and to generate plots.*