Exercise 1:
The purpose of this exercise is to train you in the application of dynamic aquatic ecosystem models and their relation to external drivers (e.g. climate change scenarios, stream flow and nutrient loading). In this exercise, we will use the lake ecosystem model Water Ecosystem Tool (WET) coupled to the 1-dimensional hydrodynamic model General Ocean Turbulence Model (GOTM). To set-up the model we will use the QGIS graphical user interface, QWET.

A series of tutorial videos will help you complete this exercise (approx. 50 min. in total). The three videos demonstrate:

1. How to set up a GOTM-WET model from scratch in QWET
2. How to work with manual calibration (based on real observations)
3. How to create and run a climate change scenario

If the video tutorials are not provided during the workshop, you can access the videos here (video 1, video 2, video 3) via Vimeo.

Exercise content:

A. First, you must download and install QWET and PyNcView, and then also download the data needed for setting up a GOTM-WET model for the Shahe reservoir.

   You can find all material on the workshop page:
   https://github.com/TobiasKAndersen/wet-workshop

B. **Set-up of baseline model for Shahe reservoir**
   Set up a baseline model for the Shahe reservoir using:
   a. Location of the Shahe reservoir (available in shahe_data.xlsx)
   b. Hypsograph of the Shahe reservoir (available in shahe_data.xlsx, use 33 vertical layers)
   c. Actual (local) weather input (User_shahe_meteo)
   d. Actual (local) river input (User_shahe_inflow)
   e. Set model simulation period to 2006-01-01 – 2013-12-31.
   f. Run model and look and temperature and oxygen model performance.
   g. Calibrate the model parameters *k_min* (minimum turbulent kinetic energy [m^2/s^2]) and cyanobacteria parameters.
      i. *k_min* should be set to 4.9e-6 and run the model.
      Did this change model performance for water temperature?
      What about model performance for dissolved oxygen?

ii. Now you need to determine the optimal parameter value for the maximum growth rate at 20^{o} C of cyanobacteria (c*MuMax* [1/day]) by manual calibration. Model performance for cyanobacteria chl-a conc. should be equal to or better than: RSQ > 0.65 and RMSE < 4.0 µg/L. Can you also improve the total chl-a concentration when calibrating the cyanobacteria growth rate? Which parameter value would you decide to use? (this is needed for Socrative quiz).

Hint: In the Shahe_data folder, we have provided an excel sheet to help organize the scenario results.

C. Design and run climate change scenarios

a. First create a baseline (default) simulation where you use your own calibrated cyanobacteria max growth rate or set cMuMax to 0.3875 day^{-1}. Then, run a baseline (default) simulation for the period: 2006-01-01 (12:00:00) to 2013-12-31 (12:00:00)

Now, design and run 3 individual climate change scenarios where the air temperature input is increased by 2, 3 and 4 degrees, respectively, and use QWETcheck to:

b. extract summer mean chlorophyll a concentration for baseline and climate scenarios for year 2011, 2012 and 2013 and calculate mean of all three years for summer mean chl-a conc. Important: we are only interested in surface (epilimnion) chl-a conc., so set lower depth range for extraction to -5 meters.
Then, calculate relative change (scenario / baseline) in summer mean chl-a conc. for the three scenarios (this is needed for Socrative quiz).

c. Visually explore other state variables e.g. total nitrogen and dissolved oxygen, to gain a more complete picture of lake water quality under climate change scenarios.

D. Design and run climate change scenarios where the air temperature input is increased by 3, **<u>and</u>** combine this with your own range of scenarios where you **<u>reduce</u>** the external nutrient load (by increments of 5% - changing all nutrient fractions with an equal percentage).

a. How much must the external nutrient load be reduced in order for the Shahe reservoir to have approx. the same average conc. of mean

summer chl-a (for 2011 – 2013) in the 3 degree warming scenarios, compared to the current baseline conditions (no climate warming)?

When you have completed the exercise, we would like to get feedback on your results and your thoughts on the exercise. Therefore, please go to Socrative and complete the quiz: https://b.socrative.com/login/student - use Room name: WETMODEL. When signing in to the quiz you are welcome to use whatever name you feel comfortable with.