GLEON Student Site Exchange Report

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I am an undergraduate student who was provided with funding to support a GLEON student exchange with the University of Waikato in New Zealand. My study site is Lake Balaton in Hungary, which is very shallow (mean depth 3.2 m) and large (596 km^2). I began studying Lake Balaton approximately one year ago. In June-July 2009, I got a chance to work with Prof. David Hamilton at Waikato University, Hamilton, New Zealand as part of the GLEON student exchange. The purpose of this exchange was to get acquainted with the one-dimensional hydrodynamic model DYRESM and its coupled ecological model CAEDYM. During the six weeks in New Zealand I participated in several workshops where we shared our experience in connection with modeling. I also attended seminars (e.g., Dennis Trolle's PhD defense and a conference of 'Lake Ecosystem Restoration New Zealand – LERNZ'). In my project I spent a great deal of time obtaining correct input data, especially radiation. Amongst the input data required for DYRESM-CAEDYM simulations is short- and long-wave radiation or cloud cover. Only global radiation was available so I created a model to estimate cloud cover from global radiation. First I defined the theoretical maximum and the theoretical minimum curves for a given day of the year, according to the European Solar Radiation Atlas, ESRA[1,2] . I then calculated the Linke Turbidity Factor using an average value from ESRA. The turbidity factor depends on the relative optical air mass and this value is correct when the air mass is two, but the relative optical air mass changes with time because it is a function of the solar altitude angle. For this reason I examined five different relationships to calculate the Linke Turbidity Factor. The conclusion of this examination was that the Dogniaux's relationship[3] gave the closest results. From the theoretical curves I could estimate cloud cover by linear interpolation between the theoretical maximum and minimum. Using this model I created the input data of required for the meteorological file input for DYRESM-CAEDYM and I then calibrated the water balance with the runoff of Sio canal.

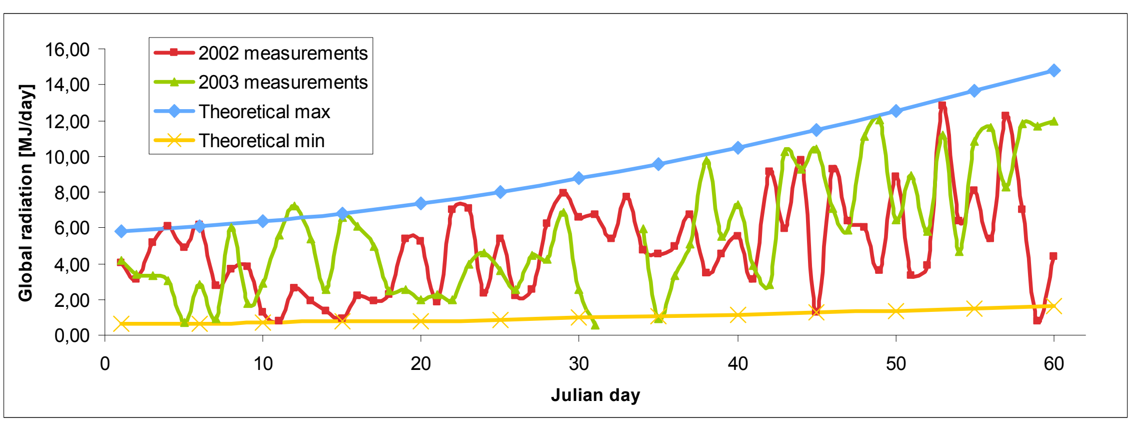

Figure 1. Global radiation as a function of Julian day

The next step was to calibrate the concentration of suspended solids in the lake. This variable depends on the water level and wind speed. Turbidity is important in determining the amount of light attenuation in the water column. I worked with the latest version of CAEDYM, where turbidity depends on 40-50 parameters. I got the best result with the following values assigned to the major parameters that control suspended solids concentrations and, by implication, levels of turbidity: density = 0.24×10^4 kg m^{-3}, diameter = 2.5×10^{-6} m, specific attenuation coefficient = 0.05 m^2 (mg $SS)^{-1}$, critical shear stress for sediment resuspension 0.001 N m^{-2}. With these parameters the root-mean-square error (RMSE) for comparisons of simulated SS against measured values in the lake was 40.83mg/l and the correlation coefficient, R^2 was 0.75.

I noted seven discrepancies that contributed to the relatively high RMSE value and these all appeared in similar situations. Removal of these seven discrepancies, from the 33 data points resulted in a RMSE value of = 3.73 and R^2 of 0.98. These situations can be related to the following problem: Lake Balaton is very long (79 km) and relatively narrow (max. width 14km). For this reason the wind direction, which determines the fetch, has a great influence on the generation of wind waves and the resultant sediment resuspension. DYRESM does not calculate fetch as there is no wind direction input into the model.

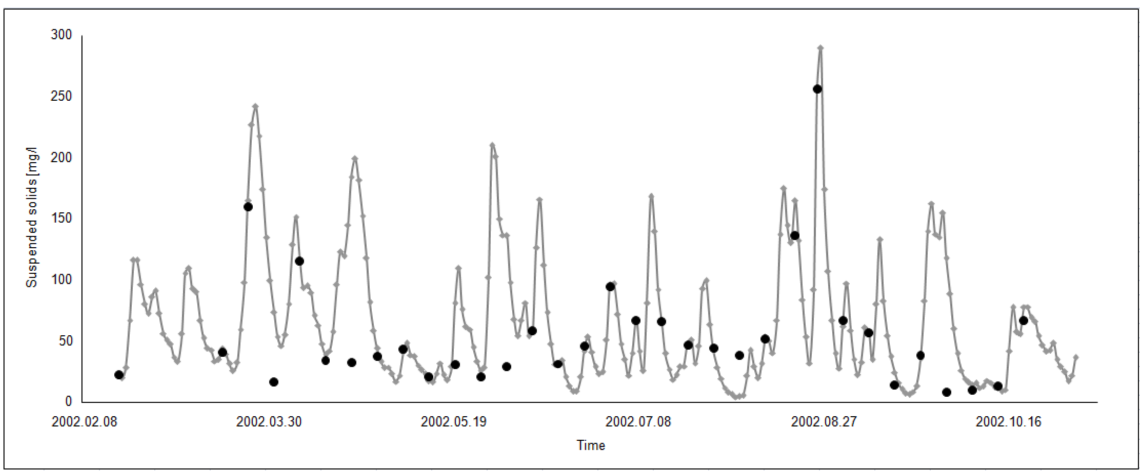

Figure 2. Simulated SS concentration (solid line) and measured SS concentration (black points).

If this problem is solved, then DYRESM will be better able to be adapted to lakes of different shapes and sizes, and should be able to reproduce excellent simulations of variations in suspended solids concentrations resulting from wave action in shallow lakes.

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References:

[1] Rigollier Christelle, Bauer Olivier, Wald Lucien. On the clear sky model of the ESRA-European Solar Radiation Atlas with respect to the Heliosat method. Groupe Télédétection & Modélisation, Ecole des Mines de Paris

[2] K. Scharmer and J.Greif. The European Solar Radiation Atlas, Les Presses de l'École des Mines, Paris, 2000.

[3] C. P. Jacovides. Model comparison for the calculation of Linke's turbidity factor. International journal of Climatology, 1998.