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Long-term Simulation Study about the Impact of submerse Macrophytes on thermal Stratification Dynamics and Transport Processes in an extreme shallow water lake – Lake Federsee

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Lake Federsee is formed primarily by ice age processes and was subjected to strong siltation processes in post-glacial times, while in the last two centuries anthropogenic impact due to amelioration projects became more important and determined it's morphometry. Lake Federsee has a maximum length of 2.4 km, a maximum width of 1.1 km and an area of approx. 1.4 km2. With respect to it's area Lake Federsee is the third largest lake in the federal state of Baden-Wuerttemberg situated in the south of Germany. It is characterized by its very flat bathymetry with a maximum depth of about 3.15 m and an average depth of about 1 m.
In recent years Lake Federsee has undergone a strong reduction of the nutrient content, thus developing from hypertrophic states in the years 1980ies to eutrophic conditions in the years 2000ies. Since 2005 this development is accompanied by a change of the general habitus of the lake converting from a lake dominated by algae to a lake dominated by macrophytes.
Changing successions of aquatic plants have been observed in the lake with strong seasonal variations in the composition and density of the vegetation cover, however forming often an almost complete coverage of the lake.
In the present study the implementation of the hydrodynamic, three-dimensional model DELFT3D - FLOW for this extreme shallow water lake will be presented. The impact of some numerical parameters will be investigated in a sensitivity study, which is aiming to set up the hydrodynamic model in an optimal way.
This 3-dim hydrodynamic model is used to simulate the 3-dim flow field and to investigate the thermal stratification as well as the mixing processes taking place in this lake. The model is run for the simulation time period 2000 – 2016 having a horizontal resolution of dx=dy=50 m and 10 or 20 equidistantly spaced fixed vertical layers giving a vertical resolution of 0.32 or 0.16 m respectively. The timestep is choosen to be dt = 10 s.
Analysis of the simulated vertical temperature profiles shows that the lake nevertheless very shallow undergoes periods of distinct and stable thermal stratification which can last up to 10 days giving the right meteorological conditions (calm and warm). The overall vertical temperature gradients are in general stronger in "warm" years than in "cold" years. Furthermore we find most pronounced vertical temperature gradients during summer time whereas during months with smaller positive heat exchange temperature gradients are not as strong.

Additionally the influence of the submerse macrophyte population on both - general circulation processes and the vertical mixing processes in the lake – are discussed. It is shown by numerical simulation studies that both – circulation pattern and mixing processes - are influenced severely by macrophytes in the lake slowing down the 3-dim flow field and decreasing vertical mixing processes leading to more and more pronounced stable stratified conditions in the lake.