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HYCLIC Hydrology & Climate Change Impacts Lab

Application of a 2D-Hydrodynamic Model to Assess the Impact of Spring Water Discharge into Lake Pamvotida in Ioannina, Greece

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Introduction

The Greek Biotope Wetland Centre conducted a study to assess the minimum water level (WL) requirements of Lake Pamvotida, which should be maintained within the range of 469.10 - 468.20 m, a.m.s.l. However, the lake is susceptible to larger reductions in its water level in late summer due to increased evaporation and over-pumping for irrigation. The study investigated the introduction of freshwater from Sentenikos and Kalithea Springs into Lake Pamvotida to mitigate the decrease in its water level during the dry season. The results revealed a notable alteration in the lake's water level fluctuations, accompanied by measurable impacts on Temperature and Biochemical Oxygen Demand (BOD).

Study area

- Lake Pamvotida, is located in Ioannina Municipality, in the west of Greece (Figure 1)
- The water level is regulated by a spillway and gate ranging from 468.0 to 469.5 m a.m.s.l.
- The lake's mean depth is 5.4 m, with a maximum depth varying from 7.5 to 8.0 m (Figure 1)
- Covering an area of approximately 22 km², the estimated volume is about 118.6 million m³ at its overflow level

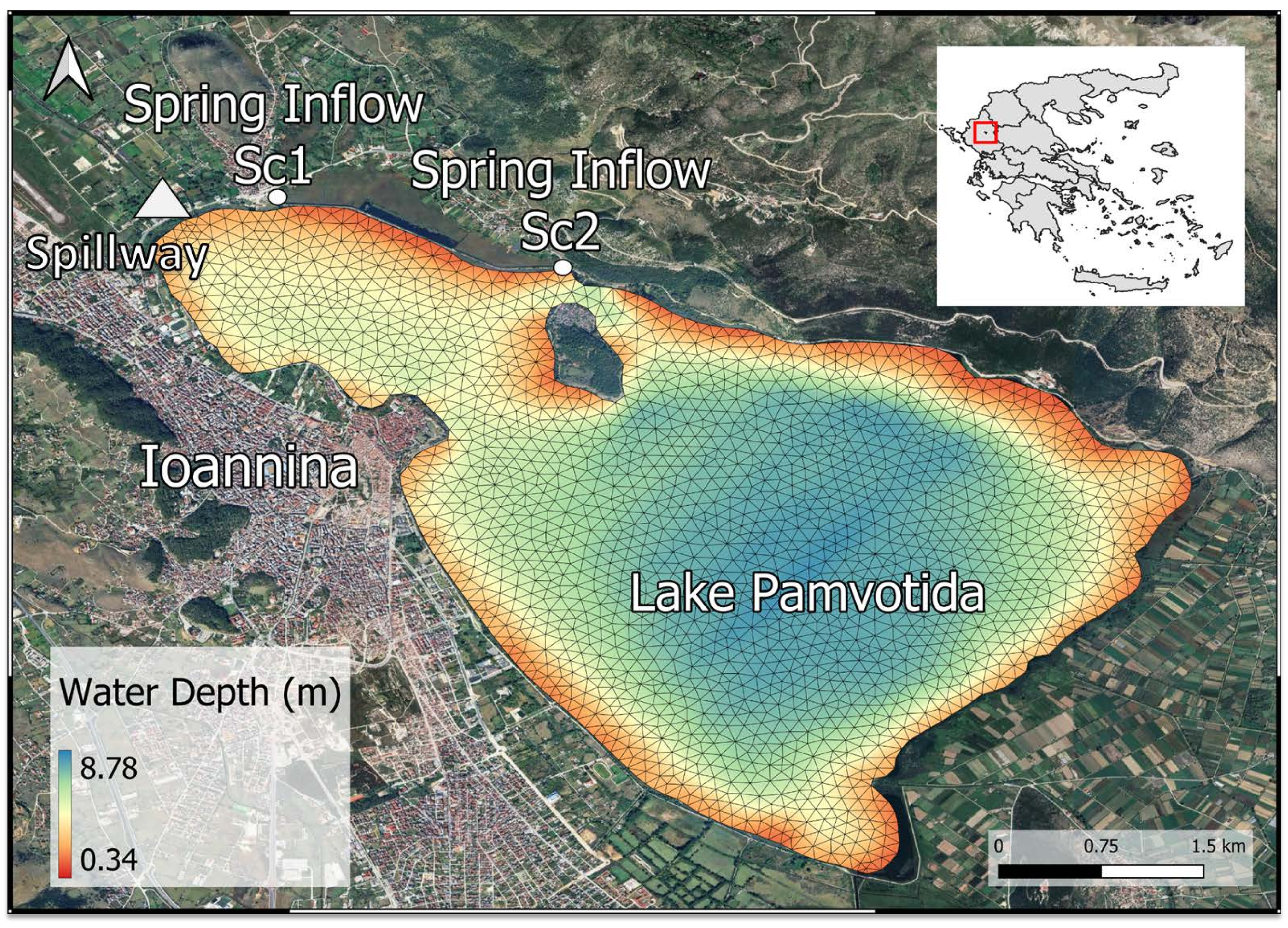

Figure 1. The mesh grid and lake bathymetry. White dots indicate the locations of spring water inflow

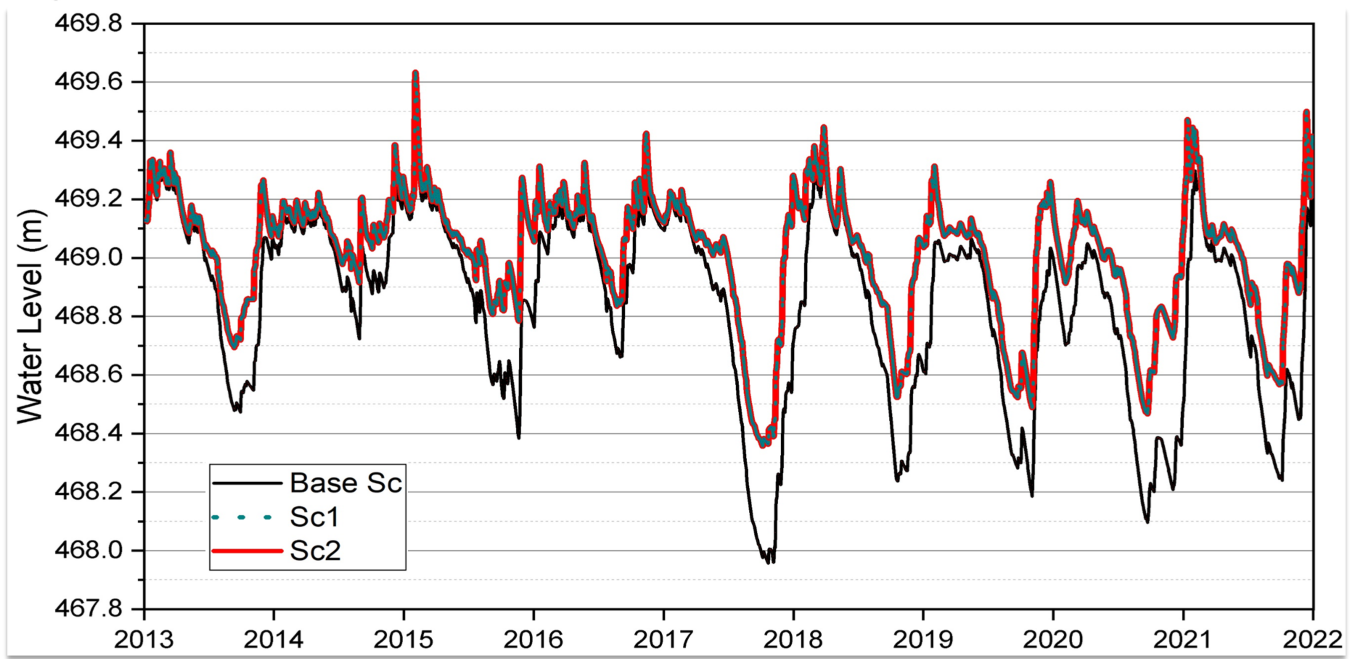

Figure 2. WL fluctuation for the Base Simulation (black), Sc1 (grey) and Sc2 (red)

Materials and methods

The 2D MIKE 21 Flow Model (FM) was used to simulate the hydrodynamic environment of the lake

- The MIKE ECO Lab module simulates the spatial distribution of water quality
- Three different simulations were investigated over nine years (2013-2021), including:
  - o the Base Simulation without spring water inflow
  - o two scenarios assess the effect of spring water inflow from two different locations
- The Base Simulation was calibrated and validated against monthly data of WL, T, and BOD for the period of 2013-2021
- The parameterization of the Base Simulation after its calibration was kept the same for the simulations of Scenario 1 and 2

Results

Spring water inflow significantly influences seasonal water level (WL) fluctuations. Scenarios 1 (Sc1) and 2 (Sc2) show similar effects, with an average WL difference of 0.17 m from the Base Simulation. During high WL periods, Sc1 and Sc2 are slightly elevated (+0.05 m), while during low WL periods, they are notably higher (+0.40 m) (Figure 2).

The impact of spring water on physicochemical conditions, such as Temperature (T), Dissolved Oxygen (DO), and Biochemical Oxygen Demand (BOD), is limited to areas near the spring inflow. After high discharge events, the water forms a plume reaching about 0.26 km² in Sc1 and 0.38 km² in Sc2. The smaller extent in Sc1 is due to its closeness to the spillway, allowing part of the inflow to exit the system rapidly (Figure 3).

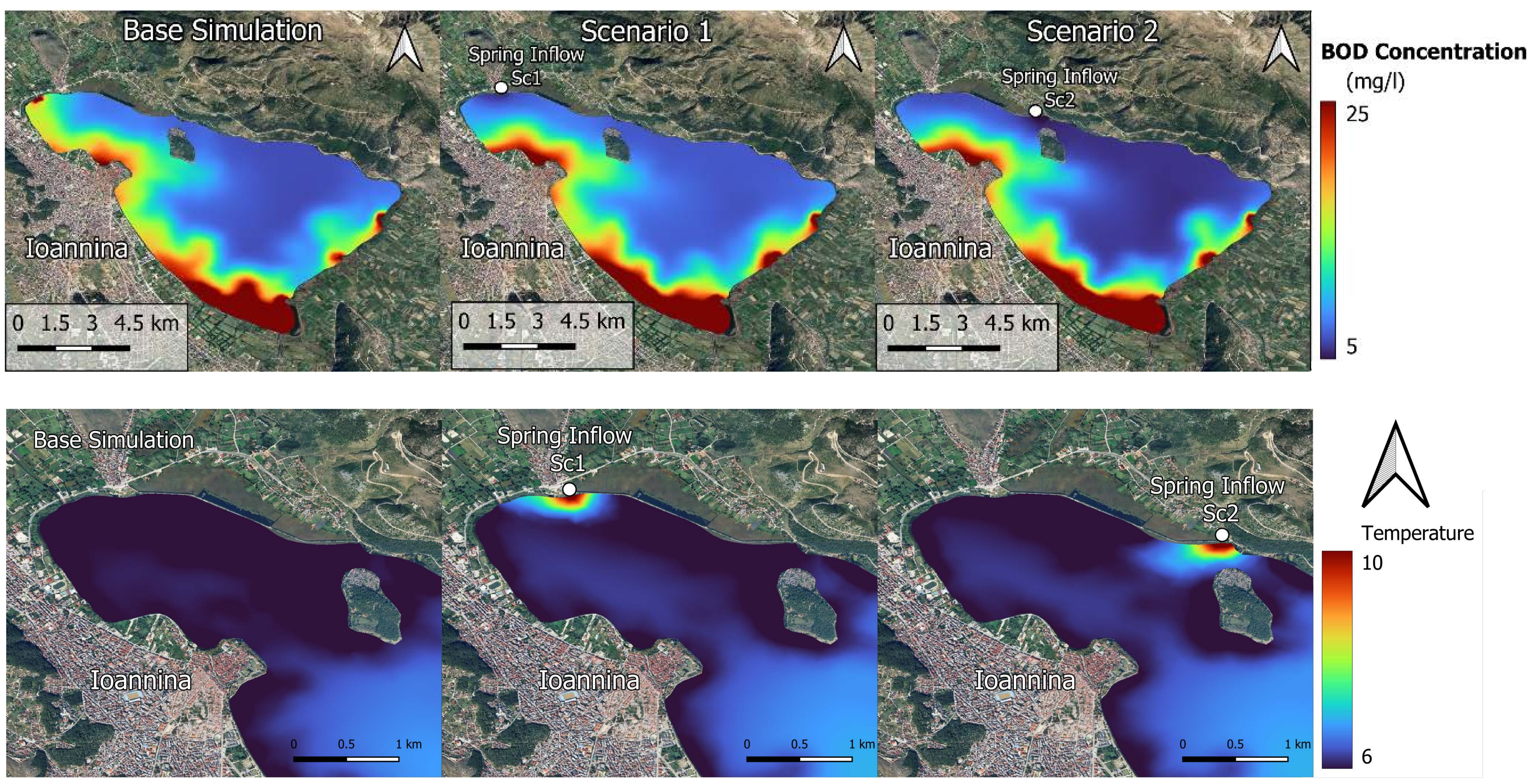

Figure 3. Indicative results from the Base Simulation and the two scenarios simulating the BOD and T influence of the spring water inflow (12.5 m³/s on October 21, 2014).

Conclusions

Spring water inflow into Lake Pamvotida significantly affects water level fluctuations, particularly during low-water periods, keeping the water level near the critical minimum of 468.20 m. Although the distinct physicochemical properties of the spring water have a limited spatial impact, restricted to areas near the discharge point, the combined effect of water level stabilization and spring inflow contributes to improved water quality in these regions.

Scenario 1 improves water quality in the northern lake region but loses effectiveness due to outflow through the spillway.

Scenario 2 has a stronger influence on the central and southern areas, where environmental degradation is more severe.

Acknowledgments

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