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Modelling thermal stratification in river waterholes using GLM

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Abstract: Thermal stratification strongly shapes algal bloom risk and hypoxia in surface waters. In rivers, however, persistent stratification has often been assumed unlikely because turbulent flows promote mixing; as a result, monitoring and modelling programs can overlook it. Australia, the second driest continent on Earth, faces significant water management challenges. During summer, many channels contract into isolated waterholes that act as ecological refuges for fish and invertebrates, and they often stratify. These stratified pools are vulnerable: rapid disturbances (e.g., wind bursts, convective cooling, storm inflows) can mix oxygen-rich surface layers with hypoxic bottom waters, triggering abrupt reduction in the dissolved oxygen resulting in fish-kill. Understanding when and why stratification forms, persists, and collapses in river waterholes can help prevent the mass fish-kill events.

This study evaluates the ability of the one-dimensional General Lake Model (GLM) to reproduce stratification dynamics in riverine waterholes and to identify the dominant environmental drivers. GLM captures the movement of heat, momentum, and mass within the water column, accounting for influences such as atmospheric conditions and water inflows and outflows (Hipsey et al. 2019). While GLM has been shown to capture overall temperature and stratification trends in lakes and reservoirs, studies on its applicability to river waterholes remain scarce. We analyse a one-year observational dataset of vertical temperature profiles from waterholes on the Glenelg and Wimmera Rivers (Victoria, Australia) and compare these to GLM simulations configured with local geometry and hourly meteorological and hydrological forcings. The modelling targets a single scalar objective of RMSE of temperature profiles across depths and time.

To keep the workflow efficient, we first apply a sensitivity screening to rank parameters that control surface heat exchange (e.g., shortwave and wind factors, light extinction). We then calibrate only the influential parameters within physically plausible bounds, using a robust, derivative-free search to obtain a best-fit parameter set. Finally, we quantify uncertainty by exploring parameter ranges consistent with the data and report credible intervals for the most influential parameters. The results provide a coherent, transferable framework for diagnosing stratification in river waterholes, clarifying the relative roles of solar irradiance, air temperature, wind speed and turbidity. We argue that a carefully tuned GLM—paired with sensitivity-aware calibration and uncertainty analysis—can serve as a simple yet powerful decision tool for managing thermal refugia in regulated, drought-prone rivers. It supports early-warning thresholds for fish-kill prevention, guides sensor placement and sampling effort, and stress-tests refugia under heatwaves and prolonged low-flows

Keywords: *General Lake Model (GLM); thermal stratification; hypoxia; river waterholes*

REFERENCES

Hipsey MR, Bruce LC, Boon C, Busch B, Carey CC, Hamilton DP, Hanson PC, Read JS, De Sousa E, Weber M and Winslow LA (2019) A General Lake Model (GLM 3.0) for linking with high-frequency sensor data from the Global Lake Ecological Observatory Network (GLEON). Geoscientific Model Development 12(1), 473–523

