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A dynamic system theory approach to identify contaminant trapping zones in Vembanad Estuary using Lagrangian Coherent structures

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Vembanad Estuary is located in the southern part of India and is also the country's longest lake. Its outlet to the Arabian sea is near Cochin. Particle trapping is one of the main issues found in this estuary. It causes the contaminants to stay in the region for extended durations, which can cause multiple problems. A large number of pollutants enter the Vembanad estuary due to the six rivers that discharge in the Vembanad lake. It is essential to comprehend the movement of these contaminants through the estuary to identify their effect on aquatic ecology and water quality. Flow in the lake is affected by numerous forcing parameters like inflowing rivers, tides, and other boundary conditions. The lack of standard methods to model particulate flow in such a complex environment poses a challenge in understanding flow dynamics and requires identifying new modeling methods.

In the present work, various sections of Vembanad are simulated to identify the trapping zones of the system. Lagrangian simulations of these individual parts of the lake are performed. The simulation results are further analyzed to obtain Lagrangian coherent structures (LCS) using Finite-Time Lyapunov Exponents (FTLE). LCS based on maximum FTLE values shows the dynamic boundaries present in the system, which help identify regions where potential trapping of non-inertial contaminants can occur. Lagrangian particle tracking also aids in recording the total movement of particulate matter from its initial position, which is used to find the resident time of these particles. The result of the study can also be used to find the potential risk posed by the non-inertial contaminants at a location based on their resident times.