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On the chaotic properties of shallow lakes

M. Pattantyus-Abraham (1), J. Jozsa (1), T. Kramer (1), T. Tel (2)

(1) Department of Hydraulic and Water Resources Engineering, BME University, Hungary, (2) Department of Theoretical Physics, ELTE University, Hungary (pattantyus@vit.bme.hu)

In the last decades the analysis of chaotic features of dynamic systems has become a new aspect in revealing system behaviour. Satellite and airborne observations have provided both qualitative and quantitative information on processes accompanied with the development of filamental structures in open flows (e.g. plankton blooms and ice curls in the seas, as well as the distribution of ozone concentration in the atmosphere). The resolution improvement in remote sensing technology has made these filaments detectable also in smaller scale inland waters thus indicating the presence of chaos in such conditions. These findings have put lake and reservoir mixing processes into a definitely new light. As representative case studies, in our work we focus on exploring chaotic mixing properties in shallow lakes, where the unsteady hydrodynamics is driven by various periodical wind forcing. Having learnt the main features in simplified test cases, the large shallow lakes in Central-Europe will be considered as real life examples. In the analysis flow velocity fields with realistic wind forcing are numerically modelled, in which methods to identify strong and weak shearing sub-regions and visualise mixing are applied and compared to each other. Techniques to determine the distribution of various indicators such as the finite size Lyapunov-exponents (FSLE) or residence time (which play an important role in hydrobiology) are implemented. These fields can help then in finding important governing elements such as stable and unstable manifolds which play the role of Lagrangian barriers hindering local transversal material transfer, and avenues significantly channelling transport in the inherently unsteady advective flow field.