EGU General Assembly 2024

EGU24-13180, updated on 09 Nov 2024
https://doi.org/10.5194/egusphere-egu24-13180
EGU General Assembly 2024

Route to chaos and resonant triads interaction in a truncated Rotating Nonlinear shallow-water model

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The route to chaos in a truncated rotating shallow-water model has been investigated by constructing an autonomous five-mode Galerkin truncated system with complex variables. Two distinct transitions to chaos were observed as the energy injected into the system increased. The first transition is characterized by forming a continuous sequence of bifurcations that follow the usual Feigenbaum path. The second transition, occurring for high values of injected energy, exhibits a sharp transition between quasi-periodic states and chaotic regimes. The first chaotic regime arises since nonlinear interactions are principally dominated by inertial terms, while the second one is related to the increasing importance of free surface elevation in the overall process. By rewriting the system in terms of phase and amplitude, for each variable truncated system, it has been found that phases are locked at the initial value for a certain period of time, followed by a sudden transition due to a simple rotation of $\pm \pi$, even when amplitudes show a chaotic dynamic. The time duration of phase locking decreases as the injected energy increases, and, for high values of injected energy, even phases reach a chaotic regime. This behaviour is observed since, in the nonlinear term of the equations, phases appear through linear combinations of triads of different modes. When the duration of locking periods is different for each mode, the superposition of multiple π phases jumps, making the dynamics of the coupled phase triads stochastic, even for small values of the injected energy.