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Nonlinear wave evolution and runup in inclined channels

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Nonlinear wave dynamics of long water waves is studied in an inclined channel of a parabolic cross-section. Such situation occurs when sea waves enter and propagate in a narrow bay or a fjord. Nonlinear shallow water equations can in this case be written in 1D form and solved analytically with the use of the hodograph transformation. This approach generalizes the well-known Carrier-Greenspan transformation for long wave runup on a plane beach. In the case of an inclined channel of a parabolic cross-section it leads to the associated spherical symmetrical linear wave equation. As a result, the solution of the Cauchy problem can be expressed in terms of elementary functions and has a simple form (with respect to analysis) for any kind of initial conditions. Wave regimes associated with various localized initial conditions, corresponding to problems of evolution and runup of N-waves and wind set-down and set-up relaxation, are considered and analyzed. Special attention is paid to the wave breaking criterion, which appears to provide a condition of applicability for the hodograph transformation. The wave breaking condition is obtained and discussed for each of the studied problems.