Asymptotic expansion of the solutions to a regularized Boussinesq system

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We consider the propagation of surface water waves described by the Boussinesq system. We introduce a regularized Boussinesq system obtained by adding a non-local pseudo-differential operator define by $\widehat{g_\lambda[\zeta]} = |k|^\lambda \hat{\zeta}_k$ with $\lambda \in]0, 2]$.

Now, we display a twofold approach: first, we study theoretically the existence of an asymptotic expansion for the solution to the Cauchy problem associated to this regularized Boussinesq system with respect to the regularizing parameter ϵ. Then, we compute numerically the function coefficients of the expansion (in ϵ) and verify numerically the validity of this expansion up to order 2. We also check the numerical L^2 stability of the numerical algorithm.