Stockholm University

Mathematical Statistics
Stockholm University
Bachelor Thesis **2026:14**
http://www.math.su.se

Taming the Stochastic Ocean: A Numerical Study of the Stochastic Primitive Equations with Varying Bathymetry

Sebastijan Babic*

May 2026

Abstract

Ocean simulations cannot resolve every small-scale process (wind, turbulence, fine currents), so these are represented by a *random* forcing added at every time step, modelled here as a Q-Wiener process. This creates a numerical puzzle: making the time step smaller, which normally improves accuracy, can instead cause the surface pressure to fluctuate wildly from one step to the next. Since currents are driven by the pressure gradient, this instability feeds straight into them.

Theory shows the instability does not appear if the forcing is *solenoidal*, meaning the horizontal gradient of its vertical integral through the water column vanishes. On a flat sea floor, a *splitting scheme* controls the pressure gradients even for non-solenoidal forcing. This thesis tests by experiment what happens when the forcing is non-solenoidal and the sea floor is no longer flat. The instability is measured by the squared horizontal variation of the surface pressure gradients, summed over time steps and averaged over Monte Carlo samples. Across the four cases (solenoidal vs non-solenoidal, flat vs bumpy), splitting shrinks the measure by a factor of about 30 in the non-solenoidal cases and has no effect in the solenoidal ones. The measure does not diverge as Δt is refined to 10^{-3}; it remains bounded across the tested range. A factor-of-ten gap between solenoidal-flat and solenoidal-bumpy is traced to extra terms that appear only on a sloped sea floor; rigorous bounds remain future work.

*Postal address: Mathematical Statistics, Stockholm University, SE-106 91, Sweden. E-mail: sebastijan.sthlm@gmail.com. Supervisor: Josefin Ahlkrona.