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Asymptotic convergence of sampling uncertainty in a 100,000 member ensemble using an idealised model of convection

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The ensembles used to produce probabilistic weather forecasts are limited by the availability of computational resources. This can lead to large sampling error and poorly resolved ensemble distributions. Furthermore, the expense of large ensembles makes it difficult to determine how many members would be needed to achieve a desired level of sampling uncertainty. A 100,000 member ensemble from a 1-dimensional idealised prediction system which replicates the key processes of convection is developed to examine how sampling error of random variables converges with ensemble size. Distributions of the three prognostic variables, evolving over 24 hours of a free-run, are found to correspond to the three categories of distribution that were identified in a study of a 1000-member NWP ensemble, indicating that the idealised model can represent key aspects of the forecast uncertainty. Bootstrap samples from the 100,000-member distributions are used to obtain widths of the 95% Confidence Interval of various sampling distributions, as function of ensemble size n. For sufficiently large ensemble size, the confidence intervals were found to decrease proportional to $n^{-1/2}$. This scaling is universal for the mean, variance, skewness, kurtosis and several quantile random variables. The sampling error depends on distribution shape and the random variable. Techniques using parameterisation and multiple small ensemble computations are also investigated as methods to allow convergence to be estimated using smaller ensembles.