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What ensemble size is required for accurate forecasts? Idealised model experiments with very large ensembles

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Ensembles of numerical weather prediction models are currently used to represent the forecast uncertainty of forecast variables. However due to the computationally expensive nature of these ensembles, these uncertainties are only known with a large sampling error, and often the underlying distributions are assumed to be gaussian for Data Assimilation purposes. Furthermore, it is unclear how many members are required in an ensemble to obtain a designated level of sampling error. This work endeavours to understand how this error decreases as ensembles become larger, and how the forecast uncertainty evolves over a 24 hour free forecast period, before answering the pressing question of: how many ensembles are required in an NWP ensemble in order to sufficiently resolve the uncertainty? To do this, a simple 1D modified shallow water model which replicates the main features of convection is employed in the form of a massive ensemble with over 100,000 members. The shape of the distributions from this ensemble, which develop significant non-gaussianity, resembles those of the operational NWP ensembles of SCALE-RM and ICON, indicating that this model is sufficiently realistic in representing the forecast uncertainty. The simple model will be used to determine the rate of convergence of different forecast variables as ensemble size increases, and to evaluate the errors resulting from using the small ensemble sizes that are typical in operational NWP.