A framework for investigating : "How large should an ensemble be?"

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The question "How large should an ensemble be?" is one of the most recurrent questions of modern medium range forecasting. A framework is presented within which this question can be meaningfully addressed. The answer to this question is shown to vary not only with the aims of the forecast, but also with the lead-time of interest, the realism of the model (specifically, the degree of dynamical consistency between the model(s) and the system generating the target verifications), the data assimilation scheme which generates the initial conditions of the ensemble members, the noise-level in the observations and the size of the forecast-verification archive, amongst other things. In short, the appropriate size for an ensemble will depend on the details of the entire Ensemble Prediction System (EPS). Results are first illustrated within the perfect model scenario and the framework is shown to generalise to imperfect models. It suggests a quantitative view of predictability which, as expected, depends upon both the system and the model(s) at hand outside the perfect model scenario. It is shown that, in general, Lyapunov times are irrelevant to the predictability of chaotic systems and that, in some cases, Lyapunov exponents give not only a misleading but an overly pessimistic view of predictability. The application of this framework to operational Numerical Weather Prediction Ensemble Prediction Systems is discussed and the size of current operational ensembles considered.