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Urns and experimental design in climate science

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Running a computer simulation of a physical system often requires specifying values for model parameters; these model parameters may, or may not, have empirical counterparts and where such real-world counterparts exist the corresponding measurements may, or may not, be available. There is wide-ranging interest in understanding the sensitivity of model output to these parameters, understanding beyond the sensitivity of scalar outputs to infinitesimal changes in parameter value over short periods of time. Climate modelling provides an excellent example of a case where (i) one is interested in the "equilibrium" changes (ii) attempts to approximate the sensitivity of interest by interpolating in parameter space have been demonstrated to fail and (iii) one is most interested in the sensitivity of a distribution to changes in parameter, not a scalar value. The general problem is simplified and then recast in terms of sampling pebbles from an infinite series of urns. For example: given a finite number of draws and the aim of locating the urn whose pebbles have the greatest mean mass (climate sensitivity), how should one distribute resources between sampling new urns, resampling urns which are thought to be good candidates, and extracting information on the likely mass distribution of pebbles in (any) urn? A variety of sequential and non-sequential experimental designs are contrasted; their implications for future climate modelling experiments is noted. It seems likely that no general solution exists, even for some of the relatively simple problem statement.