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Constrained genetic algorithms for ensemble prediction model parameter setting

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Genetic algorithms have been used in a vast range of modelling applications, in particular for model calibration purposes, but their application to calibration of NWP and climate models has been limited. It is argued that the ensemble prediction framework used in most operational centres for medium range to seasonal prediction lends itself readily to the use of genetic algorithms for model parameter calibration. Often developments in physical parametrizations are made in isolation, and the hand-tuned parameter calibration (such as microphysical fall-speeds and CAPE closure timescales) have to be painstakingly retuned when packages of changes are combined for operational implementation. Using a genetic algorithm would allow a new model version with a package of changes to self-calibrate during a pre-implementation training phase. Each forecast cycle, the N forecast models would be assessed for their 'fitness', which would determine the probability of passing some or all of their parameter settings to the next generation of ensemble members for the following cycle. Here, a modified GA is demonstrated in which each parameter setting departure is scaled by an estimate of our certainty of the default parameter setting, which then contributes to the model metric of fitness. In this way the model is constrained in its search of optimum settings to remain within the uncertainty of the default model. The algorithm, termed "constrained genetic algorithm", is tested using the Lorenz system and then with a more complicated nonlinear modelling suite with O(10) parameters to be calibrated. Sensitivity to the parent number, mutation rate and the ensemble size is investigated. .