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On the physical nudging equations

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In this work we show how it is possible to derive a new set of nudging equations, a tool still used in many data assimilation problems, starting from statistical physics considerations and availing ourselves of stochastic parameterizations that take into account unresolved interactions. The fluctuations used are thought of as Gaussian white noise with zero mean. The derivation is based on the conditioned Langevin dynamics technique. Exploiting the relation between the Fokker–Planck and the Langevin equations, the nudging equations are derived for a maximally observed system that converges towards the observations in finite time. The new nudging term found is the analog of the so called quantum potential of the Bohmian mechanics. In order to make the new nudging equations feasible for practical computations, two approximations are developed and used as bases from which extending this tool to non-perfectly observed systems. By means of a physical framework, in the zero noise limit, all the physical nudging parameters are fixed by the model under study and there is no need to tune other free ad-hoc variables. The limit of zero noise shows that also for the classical nudging equations it is necessary to use dynamical information to correct the typical relaxation term. A comparison of these approximations with a 3DVar scheme, that use a conjugate gradient minimization, is then shown in a series of four twin experiments that exploit low order chaotic models.