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Inilialization of imperfect numerical models

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Errors in numerical forecasts arise due to errors in the initial conditions and the discrepancies between the model and nature. In a quest to reduce forecast errors, initial conditions for forecast integrations are traditionally chosen to be as close to nature as possible. When such an initial condition (analysis) is used to initialize an imperfect model that is systematically different from nature, the model will drift from a state on or near the attractor of nature to a state near the model's attractor. Such a drift will induce forecast errors. To reduce drift-induced errors, a mapping paradigm is proposed where a link (i.e., mapping vector) is established between states of nature and corresponding states on (or near) the model attractor. Observations from near the attractor of nature are moved with the mapping vector to the vicinity of the model attractor. Data assimilation is performed with the mapped observations and the mapped initial conditions are then used to initialize model forecasts to be used in the next assimilation cycle. For practical applications, the mapped initial conditions as well as the forecasts are "remapped" back to be close to nature using the mapping vector with an opposite sign. The mapping paradigm is demonstrated in a setting where a simple Lorenz model is used to generate "nature" and a modified version is used as an imperfect model. The mapping vector is first estimated as the difference between the climate mean of nature and the model. Model-related errors in the Lorenz system with the mapping algorithm are reduced by 67%, leading to improvements in the quality of both the numerical forecasts made with the imperfect model and the analyses produced with the forecasts. Considering that the mapping vector may be a function of phase space location or no long-term climatology for nature or the model may be available, an adaptive approach that can be used with a relatively small amount of data was also proposed and tested.