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Error bounds for data assimilation in dissipative systems with unbounded observation noise

Lea Oljaca, Jochen Broecker, and Tobias Kuna
University of Reading, Department of Mathematics and Statistics, United Kingdom (lea.oljaca@pgr.reading.ac.uk)

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Lea Oljača*, Jochen Bröcker, Tobias Kuna
University of Reading,
Mathematics of Planet Earth, Centre for Doctoral Training

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Data assimilation is uniquely challenging in weather forecasting due to the high dimensionality of the employed models and the nonlinearity of the governing equations. Although clearly current operational schemes are used successfully, an understanding of their long-term error behaviour is still lacking.

In this work, we study the error of some simple data assimilation schemes in the presence of unbounded noise (e.g. Gaussian) on a wide class of dissipative dynamical systems with certain properties, including the frequently used Lorenz models and the 2D incompressible Navier-Stokes equations. We exploit the properties of the dynamics to derive analytic bounds on the long-term error for each realisation of the noise in time. These bounds are proportional to the amplitude of the noise. Furthermore, we find that the error exhibits a form of stationary behaviour, and in particular an accumulation of error does not occur. This improves on previous results in which either the noise was bounded or the error was considered in expectation only.

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