

## ACCURATE DATA ASSIMILATION FOR CHAOTIC DYNAMICAL SYSTEMS

Kody J.H. Law<sup>1</sup> and Andrew M. Stuart<sup>2</sup>

<sup>1</sup> SRI UQ Center, CEMSE, KAUST, kody.law@kaust.edu.sa,  
<https://sites.google.com/site/kodyjhlaw/home>

<sup>2</sup> Warwick Mathematics Institute, A.M.Stuart@warwick.ac.uk,  
<http://homepages.warwick.ac.uk/~masdr/>

**Key words:** *Data Assimilation, Filtering, 3DVAR, Chaos, Dynamical Systems, Lorenz 63, Lorenz 96, Navier Stokes.*

The problem of effectively combining data with a mathematical model constitutes a major challenge in applied mathematics. It is particularly challenging for high-dimensional dynamical systems where data is received sequentially in time and the objective is to estimate the system state in an on-line fashion. In this case, the problem is referred to as *data assimilation*. This situation arises, for example, in weather forecasting. The sequential particle filter is then impractical and ad hoc filters, which employ some form of Gaussian approximation, are widely used. The key idea underlying the accuracy of the method can be summarized as follows. Unstable dynamical systems can be stabilized, and hence the solution recovered from noisy data, provided two conditions hold. First, observe enough of the system: the unstable modes. Second, weight the observed data sufficiently over the model. In this talk I will illustrate this for the prototypical 3DVAR filter applied to three chaotic dynamical systems of increasing dimension: the Lorenz 1963 model, the Lorenz 1996 model, and the 2D Navier-Stokes equation.

### REFERENCES

- [1] C. E. A. Brett, K. F. Lam, K. J. H. Law, D. S. McCormick, M. R. Scott and A. M. Stuart. *Accuracy and Stability of Filters for Dissipative PDEs*, *Physica D* **245**, 1, 34-45 (2013).
- [2] D. Blömker, K.J.H. Law, A.M. Stuart, and K. Zygalakis. *Accuracy and Stability of The Continuous Time 3DVAR Filter for The Navier-Stokes Equation*, *Nonlinearity*, to appear. <http://arxiv.org/abs/1210.1594> (2013).
- [3] K. J. H. Law, A. Shukla, and A.M. Stuart. *Analysis of the 3DVAR Filter for the Partially Observed Lorenz 63 Model*, *Discrete and Continuous Dynamical Systems A*, **34**, 1061-1078 (2014).

- [4] D. Kelly, K.J.H. Law, A.M. Stuart. *Well-Posedness And Accuracy Of The Ensemble Kalman Filter In Discrete And Continuous Time*. Submitted.