Vitae for Steven J. Fletcher MIMA FRMetS

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Appointments

2011-	**Research Scientist III**, CIRA/CSU
2006-2011	**Research Scientist II**, CIRA/CSU
2004-2006	**Postdoctoral Fellow**, CIRA/CSU
2002-2003	**Sessional Lecturer**, Department of Mathematics, University of Reading, UK. Courses taught and examined: Introduction to matrices (Freshman), Introduction to Control Theory (Second years and Finalists).
1998-2003	**Tutor**, Department of Mathematics, University of Reading, UK. Tutored Calculus of several variables, linear algebra, introduction to matrices, vectors and complex numbers, introduction to calculus, numerical analysis I (computer practicals in MATLAB for numerical linear algebra and splines), numerical analysis III (Computer practicals in MATLAB for numerical solutions to initial and boundary value problems).
1998-2002	**Private Tutor**. Helping G.C.S.E and A. Level students with their mathematics exams, specifically students who had dyslexia, teaching them techniques to overcome this in mathematic exams.

Degrees

2004 **Ph.D. in Mathematics**, University of Reading, United Kingdom. Thesis title: *Higher Order Balance Conditions Using Hamiltonian Dynamics for Numerical Weather Prediction.*

1999 **M.Sc. in Mathematics, Numerical Solutions to Differential Equations,** University of Reading, United Kingdom. Dissertation title: *Numerical Approximations to Buoyancy Advection in the Eady Model.*

1998 **B.Sc.(HONS) in Mathematics and Statistics**, University of Reading, United Kingdom.

Narrative of Research Experience

Since 2005 I have been undertaking research into how to relax the Gaussian assumption that is made in variational, Kalman filter, ensemble-based data assimilation algorithms. I have been able to derive lognormal based cost functions, as well as recently, a lognormal equivalent for the Kalman filter, where here that descriptive statistics that is found is the median, not the mode or the mean. I have been able to combines the Gaussian and lognormal distribution to form a mixed distribution that enables a better model of the covariances between temperature and moisture errors. The mixed distribution is in use with a near real time satellite retrieval system at CIRA/CSU where it is compared against a Gaussian fits all, and a logarithmic transformation approach. I have also derived a mixed Gaussian-lognormal version of the representer formulation, as well as the equivalent in the Maximum Likelihood Ensemble Filter. Given this theory I have also been able to extend the quality control measures (buddy check) of observations to lognormal and mixed distribution distributed errors.

Other areas of research include machine learning to detect changes in distributions to inform a variational data assimilation system to switch between a Gaussian fits all, to a mixed distribution approach. I have also worked on assimilating binary observations of snow cover, as well as combining these with coarse snow water equivalent observations.

Over the last two year I designed a climate projection algorithm for the US Army to take a 10 year period of record of observations of temperature, relative humidity, solar radiation, wind speed, and rainfall, and use these to project from a climate model means or max/mins of these fields to hourly data through preserving these statistics by mapping them to the best observation day that matched the total precipitation. This was then fed into a wild fire model to determine risks to army facilities.

I have authored two textbooks in the last five years, the first is associated with providing a resource on most of the different aspects that go into data assimilations, as well as explaining all of the techniques used in data assimilation, while the second textbook is an introduction to all different aspects of semi-Lagrangian advection modeling and applications in the geosecinces. I have just completed a third textbook that is a second edition of the Data Assimilation one to now include Lagrangian data assimilation along with how machine learning interacts with the different forms of data assimilation.

In the summer of 2020 I accepted the position of book series editor for the Elsevier series "Computational Geophysics" and have started to redesign the series to be more catered for students to enable them to see the applications of the mathematics and statistics in atmospheric and other geophysical disciplines.

Key Publications

Fletcher, S.J., 2022: Data Assimilation for the Geosciences: From Theory to Applications, 2nd edition. October 2022, Elsevier.

Fletcher, S. J., M. Zupanski, M. R. Goodliff, A. J. Kliewer, A. S. Jones and T.-C. Wu, 2021: Lognormal and mixed Gaussian-lognormal based Maximum Likelihood Ensemble Filter. To be submitted to JAMES.

Fletcher, S. J., M. Zupanski, M. R. Goodliff, A. J. Kliewer, A. S. Jones and T.-C. Wu, 2021: Maximum Likelihood Ensemble Smoother. To be submitted to JAMES.

Fletcher, S. J., M. Zupanski, M. R. Goodliff, A. J. Kliewer, A. S. Jones, J. M. Forsythe and T.-C. Wu, 2022: Lognormal and Mixed Gaussian-lognormal based Kalman Filters and Maximum Likelihood Ensemble Filters. Submitted to Monthly Weather Review.

Goodliff, M.R., S. J. Fletcher, A. J. Kliewer, A. S. Jones and J. M. Forsythe, 2022: Non-Gaussian detection using machine learning with data assimilation Applications. In print: Earth and Space Sciences

Goodliff, M., A. Kliewer, S. Fletcher, A. Jones and J. Forsythe, 2020: Detection of non-Gaussian behavior using machine learning techniques: A case study on the Lorenz 1963 model. J.G.R.-Atmosphere. 125, e2019JD031551

Fletcher, S. J., and Zupanski, M., 2006: A data assimilation method for lognormal distributed observational errors. Q. J. Roy. Meteor. Soc., 132, 2505—2519.

Fletcher, S. J., and Zupanski, M., 2006: A Hybrid Multivariate Normal and lognormal distribution for Data assimilation. Atmos. Sci. Lett., 7, 43—46.

Honors – Fellow of the Royal Meteorological Society

Memberships – American Geophysical Union, American Meteorological Society, Royal Meteorological Society, Institute of Mathematics and its Applications.