

CURRICULUM VITAE

Leonard A. Smith

Professor of Statistics

Director, Centre for the Analysis of Time Series
Department of Statistics
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Senior Research Fellow

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EMPLOYMENT

Professor of Statistics (Research), Department of Statistics, The London School of Economics and Political Science (LSE), Oct 2004-present

Director, Centre for the Analysis of Time Series (CATS), LSE, Oct 2001-present

Senior Research Fellow (Mathematics), Pembroke College, University of Oxford, UK, May 1992-present

Research Associate, Mathematics Institute, University of Oxford, UK, May 1992-present

Visiting Professor, Department of Mathematical Sciences, Durham University, Oct 2016-Oct 2017

Visiting Professor, Department of Statistics and the Computation Institute, University of Chicago, 2012-2018

Reader (Research), Department of Statistics, LSE, Mar 2000-Sep 2004

Visiting Professor, Interdisziplinäres Zentrum für Kognitive Studien, Universität Potsdam, Germany, May 1996-July 1996

Post-doc, University of Warwick, UK, Apr 1990-May 1992

Visiting Scientist, Laboratoire de Météorologie Dynamique du CNRS, École Normale Supérieure, Paris, France, Nov 1989-Apr 1990

Joint Post-doc between Department of Applied Mathematics and Theoretical Physics/Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, UK, Jun 1987-Nov 1989

EDUCATION

PhD Physics, Columbia University, Nov 1987. Thesis title: Lacunarity and Chaos in Nature.
Advisor: Prof. E.A. Spiegel

MPhil Physics, Columbia University, May 1983

MA Physics, Columbia University, May 1982

BS (with High Honors), Physics, Mathematics & Computer Science, University of Florida, June 1980

PROFESSIONAL HONORS, ACTIVITIES & MEMBERSHIP

[2013 Charney Lecturer](#) of the American Geophysical Union

[SAMSI](#) NCSU University Fellow (Data Assimilation); Statistical and Applied Mathematical Sciences Institute, Research Triangle, NC, 2005

[Fitzroy Prize](#) from the Royal Meteorological Society, 2003

[Selby Fellow](#) of the Australian Academy of Science, 2002

Fellowship: Woods Hole Oceanographic Institution [Summer School in Geophysical Fluid Dynamics](#), 1984

Fellow: The Institute of Mathematics (IoM), Royal Statistical Society (RSS)

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Member: American Geophysical Union (AGU), American Meteorological Society (AMS), American Physical Society (APS), American Statistical Society (ASA), Royal Meteorological Society (RMetS)

Scientific Committee Memberships:

[American Statistical Association Advisory Committee on Climate Change Policy](#) (2010-present);

[American Geophysical Union](#) Committee for the 2013 [AGU Position Statement on Climate Change](#);

Scientific Advisory Panel: [Smith Institute for Industrial Mathematics and System Engineering](#) (2002-present);

Research Management Committee of [MITACS](#): A Canadian Network of Centres of Excellence (2008-11);

American Meteorological Society Ad-hoc Committee on Forecast Uncertainty (2009);

World Meteorological Organization (WMO) Expert Team on Verification (2005);

[THORPEX](#) International Science Steering Committee (Co-Chair: Societal and Economic Impacts, 2001-2004);

Founding member, Scientific Steering Committee of [climateprediction.net](#) (since CASINO-21);

Secretary of the European Geophysical Society Section on Nonlinear Processes (1994-2004).

Founding Editor: [Nonlinear Processes in Geophysics](#) 1993-1997; Guest Editor in 2001 and 2003.

RECENT UNIVERSITY AND COMMITTEE SERVICE

Chair, LSE Statistics Department Research Committee; LSE Research Centre Directors' Forum; LSE Research Data Working Group; Chair, LSE CATS Steering Committee; Management Board: Centre for Climate Change Economics and Policy (LSE and Leeds); Formerly: Mathematical Institute Computing Committee (Oxford).

Refereeing: Research proposals for Australian, Belgian, British, Canadian, Dutch, European, German and American research agencies. Manuscripts for a wide range of academic journals.

RECENT CONSULTANCIES

British Broadcasting Corporation (BBC), Bermuda Institute of Ocean Sciences' Risk Predication Institute (BIOS/RPI), British Energy (also trading as Nuclear Electric), UK Department of Energy and Climate Change (DECC), Deutscher Wetterdienst (DWD), UK Department for Environment, Food and Rural Affairs (DEFRA regarding both UKCP09 and UK CCRA), Électricité de France (edf); European Centre for Medium-range Weather Forecasts (ECMWF), IG Index, Lloyd's of London, Royal Dutch Shell, Royal National Lifeboat Institution (RNLI), Science Applications International Corporation (SAIC), Scottish Power, The Smith Institute, UK Passport Agency.

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RESEARCH INTERESTS

My original research interests focused on understanding the mathematics of nonlinear dynamical systems, the analysis of observational data, and the application of insights from those two areas to increase our understanding of actual phenomena.

This core has broadened to include research questions on the communication of that understanding to the public, decision makers in industry and policy makers in government on one side, and to the philosophical foundations of uncertainty and mathematical modelling on the other. The core itself has become a chain of interlinked research topics: determining what to observe (allowing for adaptive observation); selecting a model structure or structures (from both simulation structures and empirical structures); assimilating observations into a model; estimating parameters; forming ensembles over initial condition, parameters, and model structures; evaluating ensembles; designing (probabilistic) forecasts; forecast interpretation and intercomparison (including the development, selection and use of scoring rules); decision support given the imperfection of all models; guidance for model development; improvement of experimental design. When the underlying phenomenon is simulated with nonlinear models, applied questions cannot be answered by addressing these links in isolation.

While much of my applied research focuses on geophysical systems (from the atmosphere to the entire Earth Climate System including weather, seasonal and climate prediction), I am very interested in other phenomena ranging from the UK's electricity grid and rotating machinery, through medical observations and laboratory experiments, and on to economic forecasting, catastrophe modelling for the insurance sector, and fraud detection in the UK industrial gambling sector.

In short, I aim for the development of a coherent framework for using imperfect models to better understand and predict real dynamical systems, extract insights from model output in the context of today's scientific understanding, and improve today's best models while maintaining realistic expectations of just how much that investment will return.

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RESEARCH GRANTS (SELECTED)

This table shows larger grants (over £60,000/\$100,000) held at LSE on which Leonard Smith was Principal Investigator (PI), consortia grants across multiple institutions where he leads the LSE portion (PI at LSE) or was a named co-Investigator (Co-I). On the “PI at LSE” grants, only funding to LSE is shown. Details of smaller grants and industrial funding available upon request.

Funder	Title	Role	Amount (to LSE)	Dates
EU H2020	Improving Future Ecosystem Benefits Through Earth Observations (ECOPOTENTIAL)	PI at LSE	£204,115	Jun 2015 - May 2019
NERC	Climate Science Into the Board Room (CIBR)	PI	£156,684	Oct 2014 - Mar 2016
DECC/Climate KIC	DECC Global Calculator	PI at LSE	£60,000	Sep 2013 - Aug 2015
EPSRC	Delivery and Evaluating Multiple Flood Risk Benefits (‘Blue-Green Cities’)	PI at LSE	£92,843	Jan 2013 - Dec 2015
NERC	End-to-End Quantification of Uncertainty for Impacts Prediction (EQUIP)	PI at LSE	£185,630	Jan 2010 - Dec 2012
Munich Re	Evaluating the Economics of Climate Risks and Opportunities in the Insurance Sector	PI	£2.9 million	Oct 2008 - Sep 2013
ESRC	Centre for Climate Change Economics and Policy (CCCEP)	Co-I	£4.5 million	Oct 2008 - Sep 2013
EPSRC CASE	Applied Probabilistic Forecasting	PI	£90,000	Dec 2006 - Dec 2009
NERC	Nonlinear Analysis and Prediction Statistics from Time series and Ensemble-forecast Realizations (NAPSTER)	PI	£152,481	Nov 2005 - Apr 2008
EU FP6	Ensemble-based Predictions of Climate Changes and their Impacts (ENSEMBLES)	PI at LSE	£112,926	Oct 2004 - Sep 2009
EPSRC/DTI	Direct and Inverse Modelling in End-to-End Environmental Estimation (DIME)	PI	£94,360	Mar 2003 - Aug 2005
EPSRC/DTI	Real-time Modelling of Nonlinear Data streams (REMIND)	PI	£85,827	Mar 2003 - Feb 2005
NERC	climateprediction.net	Co-I	£306,777	Nov 2003 - Oct 2006

CASE: Industrial CASE Studentships: PhD studentship funded by industry and a Research Council

DECC: UK Department of Energy and Climate Change

DTI: UK Department of Trade and Industry (now the Department for Business Innovation & Skills)

EPSRC: UK Engineering and Physical Sciences Research Council

ESRC: UK Economic and Social Research Council

EU FP6: European Union Sixth Framework Programme

EU H2020: European Union Horizon 2020 Research Framework Programme

Munich Re: A leading reinsurance company that fully funds Program 5 of the CCCEP directly

NERC: UK Natural Environment Research Council

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PUBLICATIONS

Links to papers in the public domain can be found on the [CATS website](#).

Books

Modern Analysis of Time Series with Applications to Real Data. Oxford University Press. L.A. Smith & H. Du. Expected 2016.

[A Very Short Introduction to Chaos](#) (2007) Oxford University Press. A member of the OUP "A Very Short Introduction" series. Available in English, Arabic, German, Italian, Spanish, Turkish and Vietnamese (Chinese in preparation). 12th Printing.

Lacunarity and Chaos in Nature (1987) PhD Thesis, 263, Columbia University in the City of New York.

Papers in Review

Du, H. & L.A. Smith. Rising Above Chaotic Likelihoods. *SIAM Journal of Uncertainty Quantification* (in review)

Machete R. & L.A. Smith. How Large Should an Ensemble Be? *Tellus* (in review)

Du, H. & L.A. Smith. Multi-model cross pollination in time. *Physica D* (submitted)

Published Papers

Smith, L.A. (2016) '[Integrating Information, Misinformation and Desire: Improved Weather-Risk management for the Energy Sector](#)', in Aston, P.J., Mulholland, A.J. & Tant, K.M.M. (ed.) *UK Mathematical Success Stories in Industrial Mathematics*, 289-296. Springer International Publishing Switzerland.

Thorne, C., E.C. Lawson, C. Ozawa, S.L. Hamlin & L.A. Smith (2015) [Overcoming uncertainty and lack of confidence as barriers to wide adoption of Blue-Green infrastructure for urban flood risk management](#), *J. Flood Risk Manage.*, 2015. DOI: 10.1111/jfr3.12218.

Smith, L.A., E.B. Suckling, E.L. Thompson, T. Maynard & H. Du (2015) [Towards improving the framework for probabilistic forecast evaluation](#), *Climatic Change*, DOI: 10.1007/s10584-015-1430-2.

Frigg, R., L.A. Smith & D.A. Stainforth (2015) [An assessment of the foundational assumptions in high-resolution climate projections: the case of UKCP09](#), *Synthese*, DOI: 10.1007/s11229-015-0739-8.

Hazeleger, W., B.J.J.M. van den Hurk, E. Min, G.J. van Oldenborgh, A.C. Petersen, D.A. Stainforth, E. Vasileiadou, & L.A. Smith (2015) Tales of future weather, *Nature Climate Change*, 5, 107-113.

Lawson, E., C. Thorne, S. Ahilan, D. Allen, S. Arthur, G. Everett, R. Fenner, V. Glenis, D. Guan, L. Hoang, C. Kilsby, J. Lamond, J. Mant, S. Maskrey, N. Mount, A. Sleight, L.A. Smith, N. Wright (2014) [Delivering and evaluating the multiple flood risk benefits in Blue-Green cities: an interdisciplinary approach](#). Flood Recovery Innovation and Response, 2014 Poznan, Poland. WIT Press.

Smith, L.A., H. Du, F. Niehoerster & E.B. Suckling (2014) [Probabilistic skill in ensemble seasonal forecasts](#), *Q. J. Roy. Meteor. Soc.*, 141: 1085-1100.

Bradley, S., R. Frigg, H. Du & L.A. Smith (2014) '[Model error and ensemble forecasting: a cautionary tale](#)', in Guichun C. Guo and Chuang Liu (ed.) *Scientific Explanation and Methodology of Science*, Singapore: World Scientific 2014, 58-66.

Smith, L.A. & A.C. Petersen (2014) [Variations on Reliability: Connecting Climate Predictions to Climate Policy](#), in Boumans, M., Hon, G. and Petersen, A.C. (ed.) *Error and Uncertainty in Scientific Practice*, pp.137-156, London: Pickering & Chatto.

Frigg, R., S. Bradley, H. Du & L.A. Smith (2014) [Laplace's Demon and the Adventures of his Apprentices](#), *Philos. Sci.*, 81 (1) (January 2014), 31-59.

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- Du, H. & L.A. Smith (2014) [Pseudo-orbit Data Assimilation Part I: The Perfect Model Scenario](#), *J. Atmos. Sci.*, 71 (2): 469-482.
- Du, H. & L.A. Smith (2014) [Pseudo-orbit Data Assimilation Part II: Assimilation with Imperfect Models](#), *J. Atmos. Sci.*, 71 (2): 483-495.
- Lopez, A., L.A. Smith & E.B. Suckling (2014) [Robustness of pattern scaled climate change scenarios for adaptation decision support](#), *Climatic Change*, 122 (4): 555-566.
- Suckling, E.B. & L.A. Smith (2013) [An evaluation of decadal probability forecasts from state-of-the-art climate models](#), *J. Climate*, 26 (23): 9334-9347.
- Frigg, R., S. Bradley, R. Machete & L.A. Smith (2013) '[Probabilistic Forecasting: Why Model-Imperfection is a Poison Pill](#)', in Andersen, H., Dieks, D., Wheeler, G. Gonzalez, W. and Uebel, T. (ed.) *New Challenges to the Philosophy of Science*. Springer. Berlin, Vol. 4, 479-491.
- Frigg, R., L.A. Smith & D.A. Stainforth (2013) [The Myopia of Imperfect Climate Models: The Case of UKCP09](#), *Philos. Sci.*, 80 (5): 886-897.
- Glendinning, P. & L.A. Smith (2013) [Lacunarity and Period-doubling](#), *Dynamical Systems*, 28 (1): 111-121. Du, H. & L.A. Smith (2012) [Parameter estimation through ignorance](#), *Phys. Rev. E*, 86, 016213.
- Rowlands, D.J., D.J. Frame, D. Ackerley, T. Aina, B.B.B. Booth, C. Christensen, M. Collins, N. Faull, C.E. Forest, B.S. Grandey, E. Gryspeerdt, E.J. Highwood, W.J. Ingram, S. Knight, A. Lopez, N. Massey, F. McNamara, N. Meinshausen, C. Piani, S.M. Rosier, B.M. Sanderson, L.A. Smith, D.A. Stone, M. Thurston, K. Yamazaki, Y.H. Yamazaki & M.R. Allen (2012) [Broad range of 2050 warming from an observationally constrained large climate model ensemble](#), *Nature Geoscience*, 5: 256-260.
- Beven, K., W. Buytaert & L.A. Smith (2012) [On virtual observatories and modelled realities \(or why discharge must be treated as a virtual variable\)](#), *Hydrol. Process.*, 26 (12): 1905-1908.
- Smith, L.A. & N. Stern (2011) [Uncertainty in science and its role in climate policy](#), *Phil. Trans. R. Soc. A*, 369, 1-24.
- Khare, S. & L.A. Smith (2011) [Data Assimilation: A fully nonlinear approach to ensemble formation using Indistinguishable States](#), *Mon. Weather Rev.*, 139 (7): 2080-2097.
- Ghil, M., P. Read & L.A. Smith (2010) Geophysical flows as dynamical systems: the influence of Hide's experiments, *Astron. Geophys.*, 51: 4.28-4.35.
- Oreskes, N., Stainforth, D.A. & L.A. Smith (2010) [Adaptation to Global Warming: Do Climate Models Tell Us What We Need to Know?](#), *Philos. Sci.*, 77 (5): 1012-1028 (December 2010).
- Smith, L.A., M.C. Cuéllar, H. Du & K. Judd (2010) [Exploiting dynamical coherence: A geometric approach to parameter estimation in nonlinear models](#), *Phys. Lett. A*, 374, 2618-2623.
- Hagedorn, R. & L.A. Smith (2009) [Communicating the value of probabilistic forecasts with weather roulette](#), *Meteorol. Appl.*, 16 (2): 143-155.
- Judd, K., C.A. Reynolds, L.A. Smith & T.E. Rosmond (2008) [The Geometry of Model Error](#), *J. Atmos. Sci.*, 65 (6): 1749-1772.
- Bröcker, J. & L.A. Smith (2008) [From Ensemble Forecasts to Predictive Distribution Functions](#), *Tellus A*, 60 (4): 663.
- Judd, K., L.A. Smith & A. Weisheimer (2007) [How good is an ensemble at capturing truth? Using bounding boxes for forecast evaluation](#), *Q. J. Roy. Meteor. Soc.*, 133 (626): 1309-1325.
- Stainforth, D.A., M.R. Allen, E.R. Tredger & L.A. Smith (2007) [Confidence, uncertainty and decision-support relevance in climate predictions](#), *Phil. Trans. R. Soc. A*, 365, 2145-2161.
- Bröcker, J. & L.A. Smith (2007) [Scoring Probabilistic Forecasts: The Importance of Being Proper](#), *Weather Forecast.*, 22 (2): 382-388.

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- Bröcker, J. & L.A. Smith (2007) [Increasing the Reliability of Reliability Diagrams](#), *Weather Forecast.*, 22 (3): 651-661.
- Smith, L.A. (2006) '[Predictability Past Predictability Present](#)', in Palmer, T. and Hagedorn, R. (ed.) *Predictability of Weather and Climate*, Chapter 9. Cambridge University Press [Note that this is an extended version of Smith (2003) below].
- Guerrero, A. & L.A. Smith (2005) [A Maximum Likelihood estimator for Long-range Persistence](#), *Phys. Lett. A*, 355 (2-4): 619-632.
- Roulston, M.S., J. Ellepola & L.A. Smith (2005) [Forecasting Wave Height Probabilities with Numerical Weather Prediction Models](#), *Ocean Eng.*, 32 (14-15): 1841-1863.
- Stainforth, D.A., T. Aina, C. Christensen, M. Collins, D.J. Frame, J.A. Kettleborough, S. Knight, A. Martin, J. Murphy, C. Piani, D. Sexton, L.A. Smith, R.A. Spicer, A.J. Thorpe, M.J. Webb & M.R. Allen (2005) [Uncertainty in the Predictions of the Climate Response to Rising Levels of Greenhouse Gases](#), *Nature*, 433 (7024): 403-406.
- Weisheimer, A., L.A. Smith & K. Judd (2005) [A New View of Forecast Skill: Bounding Boxes from the DEMETER Ensemble Seasonal Forecasts](#), *Tellus*, 57 (3): 265-279 MAY.
- Golobic, I., E. Pavlovic, J. von Hardenberg, M. Berry, R.A. Nelson, D.B.R. Kenning & L.A. Smith (2004) [Comparison of a Mechanistic Model for Nucleate Boiling with Experimental Spatio-Temporal Data](#), *Trans IChemE, Part A, Chem. Eng. Res. Des.*, 82 (A), 1-10.
- Judd, K. & L.A. Smith (2004) [Indistinguishable States II: The Imperfect Model Scenario](#), *Physica D*, 196: 224-242.
- Altalo, M.G. & L.A. Smith (2004) [Using ensemble weather forecasts to manage utilities risk](#), *Environmental Finance*, October 2004, 20: 8-9.
- Kwasniok, F. & L.A. Smith (2004) [Real-time Construction of Optimized Predictions from Data Streams](#), *Phys. Rev. Lett.*, 92 (16).
- McSharry, P.E. & L.A. Smith (2004) [Consistent Nonlinear Dynamics: identifying model inadequacy](#), *Physica D*, 192: 1-22.
- Smith, L.A. & J.A. Hansen (2004) [Extending the Limits of Forecast Verification with the Minimum Spanning Tree](#), *Mon. Weather Rev.*, 132 (6): 1522-1528.
- Roulston, M.S. & L.A. Smith (2004) [The Boy Who Cried Wolf Revisited: The Impact of False Alarm Intolerance on Cost-Loss Scenarios](#), *Weather Forecast.*, 19 (2): 391-397.
- Judd, K., L.A. Smith & A. Weisheimer (2004) [Gradient Free Descent: shadowing and state estimation using limited derivative information](#), *Physica D*, 190 (3-4): 153-166.
- von Hardenberg, J., T. Kono, D.B.R. Kenning, P.E. McSharry & L.A. Smith (2004) [Identification of nucleation site interactions](#), *Int. J. Heat Fluid Fl.*, 25 (2): 298-304.
- Orrell, D. & L.A. Smith (2003) [Visualising bifurcations in high dimensional systems: The spectral bifurcation diagram](#), *Int. J. Bifurcat. Chaos*, 13 (10): 3015-3027.
- Guerrero, A. & L.A. Smith (2003) [Towards Coherent Estimation of the Correlation Dimension](#), *Phys. Lett. A*, 318 373-379.i.
- McSharry, P.E., L.A. Smith & L. Tarassenko (2003) [Prediction of epileptic seizures: Are non- linear methods relevant?](#), *Nat. Med.*, 9 (3): 241-242.
- Smith, L.A. (2003) [Predictability Past Predictability Present](#), In 2002 ECMWF Seminar on Predictability. 219-242. ECMWF, Reading, UK.
- McSharry, P.E., L.A. Smith & L. Tarassenko (2003) [Comparison of predictability of epileptic seizures by a linear and a nonlinear method](#), *IEEE T. Bio-med. Eng.*, 50 (5): 628-633.
- Roulston, M.S. & L.A. Smith (2003) [Combining Dynamical and Statistical Ensembles](#), *Tellus* 55 A, 16-30.

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- McSharry, P.E., G. Clifford, L. Tarassenko & L.A. Smith (2003) [A dynamical model for generating synthetic electrocardiogram signals](#), *IEEE T. Bio-med. Eng.*, 50 (3): 289-294.
- Roulston, M.S., D.T. Kaplan, J. von Hardenberg & L.A. Smith (2003) [Using Medium Range Weather Forecasts to Improve the Value of Wind Energy Production](#), *Renew. Energ.*, 29 (4): April 585-602.
- Roulston, M.S. & L.A. Smith (2002) 'Weather and Seasonal Forecasting,' in Dischel, R.S. (ed.) *Climate Risk and the Weather Market*, 115-126, Risk Books, London. ISBN 9781899332526.
- McSharry, P.E., G. Clifford, L. Tarassenko & L.A. Smith (2002) [A Method for generating an artificial RR tachogram of a typical healthy human over 24-hours](#), *Computers in Cardiology*, 29: 225-228.
- McSharry, P.E., T. He, L.A. Smith & L. Tarassenko (2002) [Linear and nonlinear methods for automatic seizure detection in scalp electroencephalogram recordings](#), *Med. Biol. Eng. Comp.*, 40 (4): 447-461.
- Roulston, M.S. & L.A. Smith (2002) [Evaluating probabilistic forecasts using information theory](#), *Mon. Weather Rev.*, 130 (6): 1653-1660.
- Smith, L.A. (2002) [What Might We Learn from Climate Forecasts?](#), *Proc. National Acad. Sci. USA*, 4 (99): 2487-2492.
- Orrell, D., L.A. Smith, T. Palmer & J. Barkmeijer (2001) [Model Error in Weather Forecasting](#), *Nonlinear Proc.*, 8: 357-371.
- Hansen, J.A. & L.A. Smith (2001) Probabilistic Noise Reduction, *Tellus* 53 A (5): 585-598.
- Gilmour, I., L.A. Smith and R. Buizza (2001) [Linear Regime Duration: Is 24 Hours a Long Time in Synoptic Weather Forecasting?](#), *J. Atmos. Sci.*, 58 (22): 3525-3539.
- Judd, K. & L.A. Smith (2001) [Indistinguishable States I: The Perfect Model Scenario](#), *Physica D*, 151: 125-141.
- McSharry, P.E., J.H. Ellepola, J. von Hardenberg, L.A. Smith, D.B.R. Kenning & K. Judd (2002) [Spatio-temporal Analysis of Nucleate Pool Boiling: Identification of Nucleation Sites using Non-orthogonal Empirical Functions \(NEFs\)](#), *Int. J. Heat & Mass Transfer*, 45 (2): 237-253.
- Smith, L.A. (2000) 'Disentangling Uncertainty and Error: On the Predictability of Nonlinear Systems', in Mees, A.I. (ed.) *Nonlinear Dynamics and Statistics*, Boston: Birkhauser, 31-64.
- Hansen, J.A. & L.A. Smith (2000) [The role of Operational Constraints in Selecting Supplementary Observations](#), *J. Atmos. Sci.*, 57 (17): 2859-2871.
- Smith, L.A. (2000) 'Limits to Predictability in 2000 and 2100', in Haykin, S. (ed.) *Proceedings of IEEE 2000 Adaptive Systems for Signal Processing, Communications, and Control Symposium*, (IEEE, Piscataway), 129-134.
- Ziehmann, C., L.A. Smith & J. Kurths (2000) [Localized Lyapunov Exponents and the Prediction of Predictability](#), *Phys. Lett. A*, 271 (4): 237-251.
- McSharry, P. & L.A. Smith (1999) [Better nonlinear models from noisy data: Attractors with maximum likelihood](#), *Phys. Rev. Lett.*, 83 (21): 4285-4288.
- Smith, L.A., C. Ziehmann & K. Fraedrich (1999) [Uncertainty Dynamics and Predictability in Chaotic Systems](#), *Q. J. Roy. Meteor. Soc.*, 125: 2855-2886.
- Ziehmann, C., L.A. Smith & J. Kurths (1999) [The Bootstrap and Lyapunov Exponents in Deterministic Chaos](#), *Physica D*, 126 (1-2): 49-59.
- McSharry, P. & L.A. Smith (1998) 'Just Do It. Reductionism, Modelling and Black-box Forecasting', in Suykens, J.A.K. and Vandewalle, J. (ed.) *International Workshop on Advanced Black-Box Techniques for Nonlinear Modeling: Theory and Applications with Time-Series Prediction Competition*, 106-111, Leuven, K.U. Belgium, Kluwer Academic Publishers
- Smith, L.A. & I. Gilmour (1998) Accountability and internal consistency in ensemble formation, in the Proceedings of the ECMWF Workshop on Predictability, 1997. ECMWF, Reading, UK.

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- Smith, L.A. (1997) The Maintenance of Uncertainty, in Proc International School of Physics "Enrico Fermi", Course CXXXIII, 177-246, Societ`a Italiana di Fisica, Bologna, Italy.
- Allen, M.R. & L.A. Smith (1997) [Optimal Filtering in Singular Spectrum Analysis](#), *Phys. Lett. A*, 234 (6): 419-428.
- Gilmour, I. & L.A. Smith (1997) 'Enlightenment in shadows', in Kadtke, J.B. and Bulsara, A. (ed.) *Applied nonlinear dynamics and stochastic systems near the millennium*, 335-340, AIP, New York ISBN 9781563967368.
- Paparella, F., A. Provenzale, L.A. Smith, C. Taricco & R. Vio (1997) Local random analogue prediction of nonlinear processes. *Phys. Lett. A*, 235 (3): 233-240.
- Allen, M.R. & L.A. Smith (1996) Monte Carlo SSA: Detecting irregular oscillations in the presence of coloured noise, *J. of Climate*, 9 (12): 3373-3404. Part 3.
- Smith, L.A. (1995) [Accountability and Error in Ensemble Forecasting](#), in 1995 ECMWF Seminar on Predictability. Vol. 1, 351-368. ECMWF, Reading.
- Theiler, J. & L.A. Smith (1995) [Anomalous convergence of Lyapunov exponent estimates](#), *Phys. Rev. E*, 51 (4): 3738-3741. Part B.
- Smith, L.A. (1995) 'Locally Optimized Prediction of Nonlinear Systems: Stochastic and Deterministic', in Tong, H. (ed.) *Chaos and Forecasting*, 87-108, World Scientific, London. ISBN 9789810221263 (Note this is an extended version of Smith (1994c) below).
- Smith, L.A. (1995) A personal overview of nonlinear time-series analysis from a chaos perspective - *Comments Scan. J. Stat.*, 22 (4): 435-437
- Smith, L.A. (1994c) Local Optimal Prediction: Exploiting strangeness and the variation of sensitivity to initial condition, *Phil. Trans. Royal Soc. Lond. A*, 348 (1688): 371-381.
- Smith, L.A. (1994b) 'Visualising Predictability with Chaotic Ensembles', in Luk, F.T. (ed.) *Advanced Signal Processing: Algorithms, Architectures and Implementations*, SPIE 2296: 293-304. Bellingham, WA.
- Ziehmann-Schlumbohm, C., K. Fraedrich & L.A. Smith (1994) Ein internes Vorhersagbarkeits-experiment im Lorenz-Modell, *Meteorol. Z., N.F.*, 14.
- Allen, M.R. & L.A. Smith (1994) Investigating the origins and significance of low-frequency modes of climate variability, *Geophys. Res. Lett.*, 21 (10): 883-886.
- Smith, L.A. (1994a) 'Turbulence in the River Severn: A dynamical systems analysis', in Beven, K., Chatwin, P.C. and Millbank, J.H. (ed.) *Mixing of Transport in the Environment*, 383-399, John Wiley & Sons Ltd, London.
- Smith, L.A. (1993) 'Does a meeting in Santa Fe imply Chaos?', in Weigend, A. and Gershenfeld, N. (ed.) *Time Series Prediction: Forecasting the Future and Understanding the Past*, 323-344, SFI Series in Complexity XV, Addison-Wesley, Reading, MA.
- Smith, L.A. (1992) [Identification and Prediction of Low-Dimensional Dynamics](#), *Physica D*, 58 (1-4): 50-76.
- Smith, L.A. (1992) Comments on the paper of R. Smith, Estimating Dimension in Noisy Chaotic Time Series, *J. R. Statist. Soc.*, 54 B (2): 329-352.
- Allen, M.R., P.L. Read & L.A. Smith (1992) Temperature time-series? *Nature*, 355 (6362): 686.
- Provenzale, A., L.A. Smith, R. Vio & G. Murante (1992) Distinguishing Between Low-dimensional Dynamics and Randomness in Measured time series, *Physica D*, 58 (1-4): 31-49.
- Smith, L.A. (1991) '[Applied Chaos: Quantifying Complex Systems](#)', in Atmanspacher, H. et al. (ed.) *Information Dynamics*, NATO ASI Series B, Vol. 256, 97-102, Plenum Press, New York.
- Smith, L.A., K. Godfrey, P. Fox & K. Warwick (1991) [A New Technique for Fault detection in Multi-sensor Probes](#), *Control* 91, IEE Publication, 332 (1): 1062-1067.

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Thieberger, R., E.A. Spiegel & L.A. Smith (1990) 'The Dimensions of Cosmic Fractals', in Krasner, S. (ed.) *The Ubiquity of Chaos*, 197-217. American Association for the Advancement of Science, Washington DC.

Smith, L.A. (1989) 'Quantifying Chaos through Predictive Flows and Maps: Computing Unstable Periodic Orbits', in Abraham, N. and Albino, A. (ed.) *Quantitative Measures of Complexity*, NATO ASI Series B, Vol. 208, 359-366, Plenum Press, New York.

Smith, L.A. (1988) Intrinsic Limits on Dimension Calculations, *Phys. Lett. A*, 133 (6): 283-288.

Smith, L.A. & E.A. Spiegel (1987) [Strange Accumulators, in Chaos in Astrophysics](#), *Ann. NY Acad. Sci.*, 497: 61-65.

Smith, L.A., J.D. Fournier & E.A. Spiegel (1986) Lacunarity and Intermittency in Fluid Turbulence, *Phys. Lett.*, 114 A (8-9): 465-468.

Smith, L.A. & E.A. Spiegel (1985) Pattern Formation by Particles Settling in Viscous Flows, *Lect Notes in Phys.*, 230: 306-318.

Smith, L.A. (1984) 'Particulate Dispersal in a Time Dependent Flow', in Mellor, F.K. (ed.) *Dynamic Differentiation*, Woods Hole Institute Technical Report WHOI-84-44, Woods Hole, MA.

Green, A.E.S., K. Cross & L.A. Smith (1980) Improved Characterization of Ultraviolet Skylight, *Photochemistry and Photobiology*, 31 (1): 59-65.

Brief Contributions to the Literature

Smith, L.A. & D.A. Stainforth (13 September 2012) [Clarify the limits of climate models](#), *Nature, Correspondence*, 489: 208.

Allen, M.R, P.L. Read & L.A. Smith (1992) Temperature Oscillations, *Nature* 359 (6397): 679.

Acknowledged Contributions to Research Programs

Leonard Smith made significant (acknowledged) contributions to the following works:

[Climate Extremes: Recent Trends with Implications for National Security](#) (2012) by Michael McElroy and James Baker.

[A Blueprint for a Safer Planet](#) (2009) by Nicolas Stern. Bodley Head, London.

[The Stern Review](#) (2007) by Nicolas Stern. Cambridge University Press, Cambridge.

[The Rough Guide to Climate Change](#) (2006) by Robert Henson. Rough Guides Ltd, London.

Encyclopaedia Entries and Technical Reports

Elliott, J., M. Glotter, N. Best, K. Boote, J. Jones, J. Hatfield, C. Rozenweig, L.A. Smith & I. Foster (2013) [Predicting Agricultural Impacts of Large-scale Drought: 2012 and the Case for Better Modeling](#), Centre for Climate Change Economics and Policy Working Paper No. 131. Grantham Research Institute on Climate Change and the Environment Working Paper No. 111.

Smith, L.A. (2002) Predictability and Chaos in *Encyclopedia of Atmospheric Sciences* (eds.) J. Holton, J. Pyle and J. Curry, pp. 1777-1785. Academic Press.

Smith, L.A. and K. Judd (2002) OCIAM Report for [IG Index](#): On Identifying Skilful Clients and Vulnerable Markets.

Roulston, M.S., C. Ziehmann & L.A. Smith (2001) [A Forecast Reliability Index from Ensembles: A Comparison of Methods](#). Technical Report prepared for Deutscher Wetterdienst.

Smith, L.A., Roulston, M. and von Hardenburg, J. (2001) [End to End Ensemble Forecasting: Towards Evaluating the Economic Value of an Ensemble Prediction System](#), Technical Memorandum 336 29 pp. European Centre for Medium Range Weather Forecasts, Shinfield Road, Reading, UK.

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Smith, L.A. (1997) Noise Reduction on Multi-probe Data Streams. OCIAM Tech Rep 97-137-1.

Smith, L.A. (1996) On Nonlinearity in the Dynamics of Grid Frequency and its Impacts on Plant Dynamics, OCIAM Tech Report 96-137-1. Parts I and II. (for Nuclear Electric).

Gilmour, I. & L.A. Smith (1996) A Brief Overview of the Seminar on Atmospheric Predictability. Newton Institute, Nov 1996.

Contributions to the Popular Press

Invited **Forum** piece on "Climate Models as Economic Guides: Scientific Challenge or Quixotic Quest?" (Issues, Spring 2015). [Issues in Science and Technology](#), National Academy of Science. Summer 2015.

"[Climate Change by Numbers](#)" Consultant for the BBC Four documentary, broadcast 2 March 2015.

"[Trading on climate surprises...](#)" Pauline Barrieu and Leonard Smith in [Trading Risk](#), 22, 9, April 2010.

"[Making Room for Uncertainty](#)" Leonard Smith in a two-page interview by Fred Pearce of the *New Scientist*, 3 December 2008.

[Obituary of Professor Edward Lorenz](#), *The Observer*, 26 April 2008.

"[Unproven Theories Have Value](#)", *The Times*, letters to the Editor, 30 November 2007.

[Using ensemble weather forecasts to manage utilities risk](#), Mary Altalo and Leonard Smith in [Environmental Finance](#), October 2004, 48-49 ISSN 1468-8573.

"Predicting the Unpredictable" guest on BBC Radio 4 [The Material World](#), 11 April 2002.

Weather Watch in [EPSRC Newline Mathematics](#), July 2001.

"[Feeding Frenzy is short of juice](#)" in the *Times Higher Education Supplement*, 18 August 2000. A review of *The Predictors* by Thomas A. Bass.

"[Rough Survey of how ticks all add up](#)" in the *Times Higher Education Supplement* textbook guide, 26 May 2000. A review of *Econophysics* by R. Mantegna and H.E. Stanley.

Other Media Presence

Professor Smith has been quoted in news stories in *Nature*, *New Scientist*, BBC News, BBC Radio 4, the *Financial Times*, *The Daily Telegraph* (selected citations are available on the [CATS website](#)). Smith's research program has twice been the cover feature of the LSE Magazine.

CURRICULUM VITAE

Leonard A. Smith

GRADUATE STUDENTS

'e' indicates an expected date of completion. Statistics students were at LSE, while students in Departments of Physics, Maths or Engineering were at Oxford.

DPhil Students

Name	Department	Thesis title	Year
E Sienkiewicz	Statistics	Internal consistency as a tool in analysis and application of non-linear simulation	2016e
E Wheatcroft	Statistics	Improving predictability of the future by grasping probability less tightly	2016e
T Maynard	Statistics	Extreme insurance and the dynamics of risk	2016
S Higgins	Statistics	Limitations to seasonal weather prediction and crop forecasting due to nonlinearity and model inadequacy	2015
A Jarman	Statistics	On the provision, reliability, and use of hurricane forecasts on various timescales	2014
R Binter	Statistics	Applied Probabilistic Forecasting	2012
H Du	Statistics	Combining statistical methods with dynamical insights to improve nonlinear estimation	2009
E Tredger	Statistics	On the evaluation of uncertainties in climate models	2009
A Andrianova	Statistics	Simulation of temperature time-series on long time scales with application to pricing weather derivatives	2009
R Machete	Maths	Model Inadequacies in a Simple Physical System	2007
M Cuellar	Statistics	Perspectives and advances in parameter estimation of nonlinear models	2007
L Clarke	Maths	On the Detection of Rouge Data	2004
A Guerrero	Maths	Scaling Exponents of Deterministic and Stochastic Systems	2002
D Orrell	Maths	Uncertainty and Error in Numerical Weather Forecasting	2001
P McSharry	Maths	Prediction and Predictability in Nature	1999
I Gilmour	Maths	Nonlinear model evaluation: τ -shadowing, probabilistic prediction and weather forecasting	1999
J Hansen	Physics	Adaptive Observations in Spatially-extended Nonlinear Dynamical Systems	1998
J Ellepola	Engineering	Spatio-temporal Variations in Nucleate Pool Boiling	1997
M Allen	Physics	Interactions between the atmosphere and oceans on time scales of weeks to years	1992

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Leonard A. Smith

Masters Students

H Du (MSc)	Stats	Statistical Modelling of Grid-frequency Time Series	2006 Distinction
K Oliver (MPhil)	Maths	Red Noise and Chaos: Towards Consistent Nonlinear Signal Separation	2001
L Clarke (MSc)	Maths	Rogue Thermocouple Detection	1999
T Hirose (MSc)	Maths	Roll resonance: motion prediction via nonlinear dynamics	1999
S Boyle (MSc)	Maths	Applications of Optimal Filters	1998
A Guerrero (MSc)	Maths	Extracting Variations in Electricity Demand from Observed Variations in Grid Frequency	1998
D Cresswell (MSc)	Maths	Quantifying Changes in the Forcing of Nonlinear Climate Models	1997
M Flett (MSc)	Maths	Nonlinear Damage Estimation from Observed Grid Frequency Variations	1997 Distinction

CURRICULUM VITAE

Leonard A. Smith

UK Research Excellence Framework 2014: Impact Case studies

i) Improving weather forecasts to avoid disruption, damage and disaster

Summary of the impact: Research by Professor Leonard Smith and the LSE Centre for the Analysis of Time Series (CATS) on forecasting in non-linear and often chaotic systems, with particular attention to weather, has led to advances in three areas: 1) national and international weather industry products and services that are built upon state-of-the-art research and knowledge, 2) dissemination of state-of-the-art practice in forecast production and verification to national, regional and local weather centres around the world, and 3) the introduction of, and new applications in, state-of-the-art forecasting methods in industries facing high uncertainty and risk, e.g. insurance and energy.

The full case study can be viewed at: <http://www.lse.ac.uk/CATS/REF/Leonard-Smith-Weather-impact-case-study.aspx>

A video based on the study can be viewed at: <https://www.youtube.com/watch?v=t5cHaT6kb3M>

ii) Ensuring the best science-based predictions of climate change

Summary of the impact: As the realities of climate change have become more widely accepted over the last decade, decision makers have requested projections of future changes and impacts. Founded in 2000, the Centre for Analysis of Time Series (CATS) has conducted research revealing how the limited fidelity of climate models reduces the relevance of cost-benefit style management in this context: actions based on ill-founded projections (including probabilistic projections) can lead to maladaptation and poor policy choice. CATS' conclusions were noted in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) report and led in turn to the toning down of the UK Climate Projections 2009 and the 2012 UK Climate Change Risk Assessment. Members of the insurance sector, energy sector, national security agencies, scientific bodies and governments have modified their approaches to climate risk management as a direct result of understanding CATS' research. Attempts to reinterpret climate model output and design computer experiments for more effective decision support have also resulted.

The full case study can be viewed at: <http://www.lse.ac.uk/CATS/REF/Leonard-Smith-Climate-impact-case-study.aspx>

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SELECTED TALKS & PRESENTATIONS

A more complete list of talks, including some slides, can be found on the [CATS website](#).

'The Bayesian Way: Imprecision and Ambiguity' talk at the 'Data-Intensive Science and Technologies' workshop, Science and Technology Facilities Council, Didcot, UK, 14 September 2016.

Participant in 'Limits to Prediction' workshop at the Santa Fe Institute, New Mexico. 22-24 August 2016.

Discussant at the 2016 Joint Statistical Meetings, Chicago, 30 July-4 August 2016.

'Sculpted Ensembles: exploiting a modern data assimilation technique to enhance early warning of high impact events' and 'Prediction, Projection and Probability: Quantifying uncertain scientific insights regarding the far future' talks at the 36th International Symposium on Forecasting, Santander, Spain, 19-22 June 2016.

'From Termites and Penguins to Blocking and the Andes: Interpreting Models of the Earth System' talk at the Alpine Summer School 'Cross-Scale Interactions in the Coupled Geosphere-Biosphere System', Valsavarenche, Aosta Valley, Italy, 15-16 June 2016.

'Pragmatic Predictability (in the real world)' presentation at the Computation Institute, University of Chicago, 6 May 2016.

'Improving the Quantitative Interpretation of Simulation Models' workshop co-organised with Robert Rosner (University of Chicago), Banff International Research Station for Mathematical Innovation and Discovery (BIRS), Canada, 13-18 March 2016.

'Just Enough Decisive Information: flexible response via GLIMPSE' talk and 'Global perspectives: risk and uncertainty roundtable' at the 'Flood and Coast 2016: Risk, Resilience and Response in a Changing Climate' Conference, Telford, 23 February 2016.

Climate Science Day on Capitol Hill 2015 [also in 2015, 2014, 2013, 2012, 2011] Congressional visits: meeting the offices of Florida's US Senators and Congressmen as part of a multi-agency drive to provide unpartisan information, Washington DC, 9-10 February 2016.

Informed the U.S. National Academy of Sciences Committee, Washington DC, about building confidence at the 'Extreme Weather Events and Climate Change Attribution' workshop, 21 October 2015.

'Doing Science in the Dark'. Invited keynote talk at the 3rd National eScience Symposium, Amsterdam, 8 October 2015.

Pragmatic Bayes: Embracing with Model Inadequacy in Nonlinear Dynamical Systems' and Data Assimilation: What is the point? talks at a mini symposium at the Dynamic Days Europe Conference, Exeter, 6-10 September 2015.

'Pragmatic Bayes: towards extracting insight, if not numbers, from models which neither V nor V' talk given at the 'How to Build Trust in Computer Simulations Towards a General Epistemology of Validation' Conference, Hannover, Germany, 9-11 July 2015.

'Anticipating Equilibrium Systems (Clarity before Consensus)' Invited keynote talk given at the 'Non-equilibrium Dynamics of Climate: linking models to data' workshop, Dartington Hall, Devon, 5-7 January 2015.

'Weather as a Changing Climate'. Keynote talk given at the 'Health, Energy and Extreme Events in a Changing Climate' Seminar, Bad Honnef, Germany, 6-9 December 2014.

'Doing Science in the Dark: the challenges of Climate-like science' talk at the Rotman Institute of Philosophy (Western University, Canada) Library Speaker Series on Climate Change: The Philosophical Issues, London, Ontario, 29 October 2014.

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'Clarity before Consensus'. Talk given at the Rotman Institute of Philosophy (Western University, Canada) 'Knowledge and Models in Climate Science' Conference, 24-26 October 2014.

An invited co-author for a panel discussion entitled 'Treatment of uncertainty in climate change assessments' at JSM2014, Boston, 2-7 August 2014.

'Distinguishing Uncertainty, Diversity and Insight' talk at the NCAR Uncertainty Colloquium, Boulder, Colorado, USA, 30 July 2014.

'Parameters, Probabilities and Progress' talk at the 2014 Geophysical Fluid Dynamics Program at the Woods Hole Oceanographic Institute, MA, USA, 7 July 2014.

'The Decay of Information: In Theory and in Practice' talk at the Scientific and Statistical Computing Seminar, University of Chicago, 22 May 2014.

'Pseudo-orbit Data Assimilation and the Roles of Uncertainty in Multi-Model Forecasting' talk at the SIAM Conference on Uncertainty Quantification, Savannah, Georgia, USA, 31 March 2014.

Speaker at the CPNSS Workshop 'Rethinking Theory Construction in Social Science', LSE, 11 March 2014.

'Confounding Solid Science and Uncertain Modelling: Improving Climate Policy Modelling'. Talk given at the AAAS Annual Meeting, 13-17 February 2014, Chicago.

'The User Made Me Do It: Seamless Forecasts, Higher Hemlines and Credible Computation' talk at the 'Climate Science Needed to Support Robust Adaptation Decisions' Workshop, GeorgiaTech, Atlanta, USA, 6-7 February 2014.

'(Pre)Thinking National Science Contracts which Request Science Beyond the Pale' talk at the '(Re)Thinking National Climate Scenarios' Workshop, Reading, 16-18 December 2013.

'Predictability, Probability(s) and Physical Insight'. Invited Charney Lecture at AGU Fall Meeting 2013, San Francisco, 9-13 December 2013.

'Types of Uncertainty, Kinds of Probability, and (Re)Designing Climate Simulation from scratch'. Invited Kick-off Speaker at 'The role of oceans in climate uncertainty', Banff, Canada, 6-13 October 2013

'On the Use and Abuse (and rational interpretation) of Probability Forecasts' invited talk at the 'Forecasting, Monitoring, Controlling: Dealing with a dynamic world' workshop, UCL, 19-20 September 2013.

'Challenges for decision-makers facing uncertainty' plenary talk at the NERC PURE Associates workshop, Oxford, 10 September 2013.

'Aims and Means of Supermodeling by Cross-Pollination in Time' invited talk at the SUMO Summer School of the Macedonian Academy of Sciences and Arts, Ohrid, Macedonia, 2-7 September 2013.

'Dynamic probabilities, mature probabilities, and the links between data assimilation and ensemble forecasting in actual decision support'. Invited talk, Davos Atmosphere and Cryosphere Assembly, Switzerland, 8-12 July 2013.

'Predictability, uncertainty, and physical insight'. Invited talk, 'Methods of Chaos Detection and Predictability: Theory and Applications (MCDPTA13)' workshop, Max Planck Institute for the Physics of Complex Systems, Dresden, 17-21 June 2013.

'Predictability in Theory and Predictability in Practice'. Three-hour short course presented at EGU 2013, Vienna, 9 April 2013.

'Unpopular Essays of Juergen Kurths: Practicalities and Predictability'. Invited talk, Nonlinear Data Analysis and Modeling: Advances, Applications, Perspectives, Potsdam, Germany, 21-22 March 2013.

'Two-way communication with decision makers on uncertainties of climate science'. Invited talk, 2013 AAAS Annual Meeting, Boston, 14-18 February 2013.

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'Queuing the wrong U?' Talk given at the AGU 2012 Fall Meeting, San Francisco, 3-7 December 2012.

'Guidance, Information or Probability Forecast: Where Do Ensembles Aim?' talk at the International Conference on Ensemble Methods in Geophysical Sciences, Toulouse, France, 13 November 2012.

'Predictability and Understanding of Our Climate Risk: Approximations, Bugs and Insight', Keynote speech, 8th IEEE International Conference on eScience, Chicago, 8-12 October 2012.

'Probabilistic prediction without probabilities', Invited talk, the Royal Society Theo Murphy International Scientific Meeting on 'Handling uncertainty in weather and climate prediction, with application to health, agronomy, hydrology, energy and economics', 4-5 October 2012.

'Distinguishing uncertainty, diversity and insight', NCAR workshop Uncertainty in Climate Change Research: An Integrated Approach, Boulder, Colorado, 6-17 August 2012.

'Predictability and Insight: Contrasting the achievable aims of forecasting in weather like cases and climate like cases'. International Journal of Forecasting Editor's invited lecture, 32nd Annual International Symposium on Forecasting, Boston, 25 June 2012.

'Minimising Model 'Misuse': Communicating both Imprecision and Inadequacy in Uncertainty Management' presented at the Implications for Insurance of Model Dependency and Misuse event, Lloyd's Old Library, London, 6 June 2012.

LSE Executive Summer School: 'Introduction to Climate Science' June 2012 [Also in 2011, 2010].

'Extreme Modelling, Extreme theories, Extreme Statistics and the understanding of Rare, Unusual, or Extreme Events'. Invited talk, the Aggregation, Inference and Rare Events in the Natural and Socio-economic Sciences event, University of Warwick, 17-18 May 2012.

Epistemology Think Tank: New Measures for Models, University of Pittsburgh, 8-9 May 2012.

'Sustainable odds: Towards quantitative decision support when relevant probabilities are not available'. European Geosciences Union General Assembly, Vienna, 22-27 April 2012

'Probability Forecasting: Looking Under the Hood and at the Road Ahead' talk at the Oxford University Mathematical Geoscience seminar, 9 March 2012.

'When does Radical Uncertainty call for Regime Change?' Keynote presentation, Rationality and Decisions Research Network workshop 'Radical Uncertainty', Munich, Germany, 28 January 2012.

'Real-World Challenges to Data Assimilation and Uncertainty Quantification in Big Nonlinear Models' talk at the Special Statistics Colloquium, University of Chicago, 22 November 2011.

'Scientific Support for Climate Policy: Is a VVUQ analysis of today's models helpful? And where not: what then?', at the ICIS workshop 'Verification, Validation and Uncertainty Quantification Across Disciplines', Park City, Utah, 6-13 August 2011.

'Insight or Numbers? Distinguishing Climate Science from Climate' invited talk at the 'Climate science and climate change: Epistemological and methodological issues' symposium organised by the *Société de Philosophie des Sciences*. The symposium was affiliated to the 14th International Congress of Logic, Methodology and Philosophy of Science, Nancy, France, 19-26 July 2011.

'What (and who) do ensembles of climate models inform' invited talk at the 'Current Challenges in Climate Modelling in 2011' conference, University of Uppsala, Sweden, 26 May 2011.

'Insight or numerical Engineering? The Role of Simulation Modeling in Quantitative Decision Support' presented at the Midas Conference on Epistemology of Modeling & Simulation: Building Bridges Between the Philosophical and Modeling Communities, University of Pittsburgh, 3 April 2011.

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'All models are wrong but some are dangerous: Philosophical aspects of statistical model selection' presented at the workshop 'All Models are Wrong: Model uncertainty & selection in complex models', Groningen, The Netherlands, 14-16 March 2011.

'Contrasting Weather Prediction, Climate Projection and Scientific Insight: Can technical aspects of Data Assimilation tell us about the Decision Relevance of Models?' Invited talk, Grantham Institute, Imperial College, London, 23 February 2011.

'Justifying Complexity and Expense to Decision Makers' talk at the 'Equipping society for climate change through improved treatments of uncertainty conference', EQUIP Conference, Leeds, 19 January 2011.

'Scientific Modelling in Support of Decision Making: Skill and Value, Nonlinearity and Credibility' presented at the Climate Decision Making Center, Carnegie Mellon University, 22 October 2010.

'Toward decision-relevant probability distributions: Communicating ignorance, uncertainty and model-noise', presented at the International Underwriting Association's Catastrophe Modelling 2010 Seminar, 12 October 2010.

'Extracting Insight from Predictions of the Irrelevant: Can the Diversity in Our Models Inform Our Uncertainty of the Future?' Invited talk, 28th International Conference on Mathematical Geophysics Modelling Earth Dynamics: Complexity, Uncertainty and Validation, Pisa, 7-11 June 2010.

'The Bayesian's Burden: Non-linear Models, Probability and Insight'. Plenary talk, 'Models & Simulations IV' Conference, Toronto, 7-9 May 2010.

'Examining Uncertainties In Climate Models: Forecasting The Impact Of Best And Worst Case Climate Scenarios On The Future Of The ILS Market' presented with Pauline Barrieu at the 2nd ILS Summit Europe, Le Meridien Piccadilly, London, 26-28 April 2010.

'Getting beyond the statistics: Towards Quantifying the Geometry of Model Error' presented at RMetS meeting on model error, Met Office, Exeter, 8 April 2010.

'The Bayesian's Burden: Or Why Physicists Shrug and Statisticians Scoff'. Special lecture presented at the NCAS/NERC Earth System Science Spring Summer School, York, 9 April 2010.

'Uncertainty, Ambiguity and Risk in Forming Climate Policy' (with Nicholas Stern), presented at Handling Uncertainty in Science, Royal Society, London, 22 March 2010.

'Climate Models: Current Science and Common Sense' presented at the ESRC Centre for Climate Change Economics and Policy as part of the ESRC Festival of Social Science, London, 16 March 2010.

'Using Empirically Inadequate Models to inform Your Subjective Probabilities: How might Solvency II inform climate change decisions?' presented at the Oxford Maths Institute meeting on 'Climate: Methods for Model Comparison and Criticism in the context of data assimilation', Oxford, 12 March 2010.

'Translating Seasonal Forecasts into Year Ahead Hurricane Numbers: The Outlook and Some Recent Advances in ENSEMBLES' presented at Environmental Risk Management workshop (NERC + Maths KTN), Lloyds, 24 February 2010.

'Causation and explanation in our nonlinear world' presented at Barcelona Conference on Causality and Explanation in Physics, Biology and Economics, 18 February 2010.

'Examining Uncertainties In Climate Models: Forecasting The Impact Of Best And Worst Case Climate Scenarios On The Future Of The ILS Market' presented at the 7th Insurance Linked Securities Summit, New York, 28 January 2010.

'Quantitative Decision Support Requires Quantitative Use Guidance: Communicating deep-uncertainty and model-noise' presented at AGU Fall Meeting 2009, San Francisco, 15 December 2009

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'Using Ensemble Prediction Systems to improve risk management in the Energy Markets' presented at 'Weather Challenges for the Energy Market', Berlin, 9-10 December 2009.

'On Weighting Seasonal Models' and 'Evaluating Model Skill Relative to a Dynamic Climatology' posters presented at Ensembles Final Symposium, Exeter, 16 November 2009.

'Data Assimilation for Earth System Models: What's the Point?' presented at WCRP-CLIVAR: Initialization of Earth System Models for Decadal Predictions, at KNMI, Utrecht, 4-6 November 2009.

'Toward Decision-Relevant Probability Distributions: Communicating Ignorance, Uncertainty, and Model-Noise'. Presented at DEFRA/Met Office, Royal Society/Royal Meteorological Society meeting on the science of the UK Climate Projections, 15 October 2009.

'One Two Three More: Challenges to Describing a Warmer World' presented at '4 Degrees and Beyond', Oxford, 28 September 2009.

'Climate Models and their Information Content for the Insurance Industry' presented to the Association of British Insurers Climate Change Data Seminar, 27 August 2009.

'Data Assimilation: What's the point?' presented at the American Statistical Association/JSM, Washington DC, 3 August 2009.

'When might a climate model prove fit for purpose? Expected Uncertainty - or - Big Surprise?' presented at Max Plank Meeting, Dresden, 31 July 2009.

'How does the diversity in our models inform us about the uncertainty in our future? Presented at Symposium I of the Munich Re programme of the Centre for Climate Change Economics and Policy: Interpreting Models in a Climate Change Context, London, 20 July 2009.

Visegrad Summer School Lectures, Budapest, 16 June 2009.

'Seeing Through our Models: Coping with an inconvenient ignorance in a changing climate' presented at Cutting Edge Lecture, McGill University, 16 April 2009.

'Risk and Uncertainty: Understanding the Limits of Predictability' presented at GEOSS Small Sea Change: Big Business Impacts Meeting, Washington DC, 14 April 2009.

'You don't have to believe everything you compute' presented at the NERC/Maths KTN joint workshop on 'Statistical modelling of weather, climate and weather risks for insurance' at Lloyds of London Old Library, 16 February 2009.

Gave evidence to the Royal Commission on Environmental Pollution, 'Uncertainty in Climate Projections', a day of discussion supporting the RCEP study on 'Adapting the UK to Climate Change', Met Office, Exeter, 10 February 2009.

Invited keynote talk given at 'Extreme events: theory, observation, modeling and prediction', Palma de Mallorca, 10 November 2008.

'Communicating Uncertainties for those Insuring Future Climate Change', talk at 'Insuring Future Climate Change: preparing and acting today' Conference, Oslo 3-4 November 2008.

'Improving Predictions of Climate Change: living with an inconvenient ignorance. Invited keynote talk given at conference 'Climate change impacts and adaptation: Dangerous rates of change', University of Exeter, 22 September 2008.

'Model Error, Real World Risk: Probabilistic Pathways but Probably not Probabilities' seminar as part of a seminar series on 'Risk in the 21st Century', Oxford University, 24 January 2008.

'On the impact of NUMB weather on science, society and operational forecasting centres', poster presented at the 22nd Conference on Weather Analysis and Forecasting/18th Conference on Numerical Weather Prediction, Park City, Utah, 27 June 2007.

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'Valued Foresight or Useless Arithmetic: Extrapolation Models in the Service of Decision Support and Policy'. Presented at MSRI Symposium on Climate Change: From Global Models to Local Action, Berkeley, USA, 12-13 April 2007.

'Ensemble Forecasts: An Introduction to Their Statistics, Value and Application' and also 'Forecasting with the NAG Board: Results and Winners', presented at ECMWF Verification workshop (sponsored by WMO/WCRP/ WWRP/COST), 29 January-2 February 2007.

'Bayesian Physics and Decision Support in Climate-like Modelling', presented at SAMSI, 27 November 2006.

Member of a roundtable discussion at the WMO Climate Risk Conference 'Living with Climate Variability and Change', Espoo, Finland, 16-21 July 2006.

'Applying Complex Modelling Techniques to Sustainability Challenges', presented to workshop at the European Commission in Brussels, 16 June 2006.

'Insights from a Century of Forecast Errors: The Evolving Role of Nonlinearity in Operational Forecast Systems', talk at the '20 years of Nonlinear Dynamics in Geosciences' Conference, Rhodes, Greece, 11-16 June 2006.

'On the Risks of Miscommunicating Risk in Decision Support and Policy' talk at the 'Environmental Hazards and Risk Communication' Conference, Royal Society, London, 20-21 April 2006.

'Why I'm not a Bayesian' Keynote address at the Schlumberger Workshop, Oxford, 4 April 2006.

'Seeing Through Geophysical Models: Moving Beyond Naive Realism' presented at British Embassy, Stockholm, science seminar 'Predicting the Effects of Climate Change on the Arctic', 8 March 2006.

'The Energy Industry', presented at the WWRP/THORPEX Scientific Conference, "Improving the Global Predictability of High Impact Weather and a Review of Southern Hemisphere Plans for THORPEX", Cape Town, South Africa, 13-15 February 2006.

Seminars on 'Decision-making' for graduate students of the l'Ecole Nationale de la Météorologie on a training course entitled: "Observer, Prévoir, Décider: Météorologie science de l'ingénieur", Toulouse, France, 2 February 2006.

Panellist on an Oikos International Roundtable discussion 'Meeting the Risk of Climate Change: Management or Prevention?', LSE, London, 31 January 2006.

'Towards Intuitive Measures for Real-world Verification of Ensemble Forecasts (Or: How Much Does a Hi-Resolution Model Run Add to an Ensemble?)', presented at Naval Research Laboratory, Monterey, USA, 19 December 2005.

'Betting on the Forecast: Methods for Risk Management, Information Identification, and Resource Allocation in an Ensemble Weather Prediction System', presented at the Center for Ocean-Land-Atmosphere Studies (COLA), USA, 14 December 2005.

CURRICULUM VITAE

Leonard A. Smith

PUBLIC UNDERSTANDING OF SCIENCE

My 2007 book, *A Very Short Introduction to Chaos*, is one of the best-selling of the 'technical' volumes in the OUP Very Short Introduction series; it is available in Kindle and has been translated into Arabic, German, Italian, Spanish and Turkish. It is currently in its twelfth printing.

My LSE "Impact Video" [Improving weather forecasts to avert disruptions, damage and disaster](#) discussing the strengths and limitations of probabilistic weather forecasting has proven popular, with over 2000 views.

I am a member of the American Statistical Association's Advisory Committee on Climate Change Policy (ACCCP) and have worked on an Expert Team of the World Meteorological Organization on forecast verification. As the 2002 Selby Fellow of the Australian Academy of Science, I gave public lectures across Australia. I have given several radio interviews in the UK and Australia, including one program of *The Material World*, "[Predicting the Unpredictable](#)", aired 11 April 2002.

I have been actively involved with the *climateprediction.net* project since its beginnings as Casino21, and have worked with The Weather Channel on the goal of including uncertainty information in their weather forecasts. I have worked with the BBC on (and appear in the pilot of) the proposed weekly program "Turned out nicely again", which also has the aim of introducing the public to the advantages (and limits) of ensemble weather forecasting. Our work has been featured in *New Scientist* (two cover stories and one two-page interview) and other popular academic magazines.

I have a long standing interest in the public understanding of science. Between 1978 and 1984, I taught a number of special courses each consisting of six to ten classes, covering either astronomy, mathematics or computer science for gifted students in the primary grades (ages 6 to 12). These were given in various Public Schools in Gainesville, Florida and the New Lincoln School in New York City. Since that time I have given a number of lectures to school children and the general public, the latter at the invitation of the British Society for the Advancement of Science and Oxford's Department of Continuing Education, and the Australian Academy of Science, amongst others.

CURRICULUM VITAE

Leonard A. Smith

PHILOSOPHY OF TEACHING

My first classroom teaching experience was with elementary school children in Gainesville, Florida as an undergraduate teaching astronomy. Since that time I have given lecture classes to both undergraduate students and graduate students at Oxford (maths and physics) and LSE (statistics). In each setting, my goals are (i) to convey how interesting the topic is (or how interesting topics become accessible with the tools learned) and (ii) how to develop dexterity both in the use of mathematical skills taught and (iii) in the selection of the appropriate tool for the task at hand, which is often not the one easiest to employ. I have also taught invited summer schools in the applied sciences across Europe, India and America, Executive Summer Schools at LSE and short lecture series for practicing World Meteorological Organization accredited weather forecasters. These classes focus on interpreting another's analysis and learning the right questions to ask, a topic I include in my university teaching when possible.

I aim to show students how research scientists and industrial analysts struggle with a problem. This is illustrated, for example, by "real-time real time-series analysis" where I analyse a time series (the origin of which I do not know) that a TA has previously prepared using the tools of the course. This is enjoyable for the students, even more so for the TA, and helps make clear the difference between figuring something out and looking something up. A second challenge is a lack of both analytic and computational skills in incoming students, which leads to their not knowing what to do. Most students rarely if ever need to derive complex relations in practice outside the exam room, however they will need to know which button to push on the data analysis app (which analysis is appropriate to perform), how to code an analysis that is not easily purchased, and when to recognize when the results are not internally coherent (and ideally why). Today, we face the challenges of a "Google Generation" of students who often look for answers rather than construct them.

I design my exams to aid my teaching aims. I discuss the exam in the first lecture of every course I give, showing breakdowns of previous students that indicate the course is hard to fail, and hard to ace. And why understanding the material is a better exam strategy than memorizing. I include essay questions, and I believe I give the "longest" exams in LSE, in terms of the sheer number of pages of graphics and analysis, the majority of which is obviously irrelevant to those who understand the question.

I enjoy using new technology in the classroom when it advances the aim of the lecture. I find Smartboard technology extremely useful both in lectures and in tutorials, where it enhances fairness as well as reducing note taking, thereby increasing the chance for understanding. I believe in taking real-time data from the audience whenever practical; [TurningPoint](#) response handsets engage the students and inform the lecturer when students are missing critical background knowledge and when they are lost. Low-tech demonstrations (the NAG board, flipping a large number of coins five times) and colourful parables (the Three non-Floridian statisticians, the Deadly Carbon-black snake) are often much more effective than presenting detailed factual arguments when the former communicate why the answer is obvious.

Research students must get the maths right; they also need to develop sufficient insight to select the relevant calculation. One of my favourite lecturers at Columbia, Professor T. D. Lee, opened his physics lectures by saying he knew we would forget the details, that his aim was for us to take away a "road map" which we would not forget and would allow us to relocate the details as and when we needed them. I know of no better one sentence summary of my aims in academic teaching.