## Prof. Christopher John Budd OBE, FIMA, C.Math, NTF

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### Present and recent appointments

1995-Present. Professor of Applied Mathematics, University of Bath,
2020-Present. Director of Knowledge Exchange at the (Bath) Institute for Mathematical Innovation (IMI),
2022-Present. Principal Investigator for the UKRI Programme Grant *The Mathematics of deep learning* (Maths4DL),
2023-Present. KE-Hub Super Champion,
2000.-Present. Chair of Mathematics at the Royal Institution of Great Britain.
2022-Present. Fellow of Gresham College,

### Previous appointments

2016-2019. Gresham Professor of Geometry,
2000-2022. Chair of the (Bath) Centre for Nonlinear Mechanics.
2004-2010. Director of the Bath Institute for Complex Systems.
1989-1995. Lecturer/Reader in numerical analysis, University of Bristol.
1986-1989. CEGB Research Fellow in numerical analysis, Hertford College Oxford.

### Academic qualifications

1983-1986. D. Phil. in Mathematics, Oxford University, 1983-1986.
1982-1983. Part 3, Cambridge, 1982-1983, Distinction.
1979-1982. Mathematics M.A. Degree, Cambridge University, First Class Honours.

### Research Interests:

Industrial Applied Mathematics, Mathematical Modelling, Environmental Sciences, PDEs, Dynamical Systems, Numerical Analysis, Scientific Machine Learning.

### Knowledge Exchange and Public engagement:

Very active work in **Knowledge Exchange**, including attending, and organising, study groups all over the world. I was one of the founders of V-KEMS and have organised many VSGs. I worked closely with SPI-M-O during the COVID pandemic and received a governmental award for my work. I have served as KE Direcrtor of the Bath IMI for 10 years from 2015, and have seen it grow from small beginning to being a significant force in operational KE. I have been involved in the KE-Hub from the start and have been an active member ever since as a Super Champion. I set up the Bath MSc in 'Modern applications of mathematics' in2001 and work with very many companies through this,

setting up and coordinating over 300 industrially focused projects. Most of my research is inspired by industrial applications

I am a leading international proponent of mathematicaly based **Public Engagement** and my work in this field has been recognised by the award of an OBE. In particular I set up the Bath Science Festival, the Bath Communicating Maths course, have written three popular maths books, run the Bath Royal Institution maths masterclass programme, have written many articles, and have given many talks popularising maths.

**Awards, honours and distinctions**

1982. Senior Wrangler (top first class degree), Cambridge.
1991. First Prize in the international Leslie Fox competition for Numerical Analysis.
1999. Elected one of ten 'Scientists for the New Century' by the Royal Institution.
2001. ILT/HEA National Teaching Fellowship (NTFS).
2001. LMS Popular Lecturer in Mathematics.
2002. IOP Award for Outstanding Contributions to the Public Understanding of Physics.
2009. British Science Association Prize for the Best Science Festival in NSEW.
2011. Honorary Fellow of the British Science Association.
2012. University of Bath/Met Office Knowledge Transfer Award.
2015. Seelye Distinguished Fellowship, Auckland.
2015. IMA Distinguished Service Award.
2015. OBE for work in Mathematics and Science Education.
2015. LMS Prize for Communicating Maths.
2020. Joint AMS/MAA/SIAM prize for communicating mathematics.
2021. University of Bath award for leadership in public engagement.
2021. Praxis-Auril Prize for Knowledge Exchange.
2021. University of Bath Chancellor's Research Medal.
2022. University of Bath prize for PhD supervision.
2022. SPI-M-O SAMDS award for Modelling and Data Support.
2025. David Rees Prize Fellowship (University of Exeter).

**Recent offices in professional bodies**

2020-Present. Executive board for V-KEMS,
2003-2015, 2022-Present. IMA Council and Research Committee,
2024-Present. Chair of the IMA Climate Special Interest Group,
2023-Present. NESO AI Advisory Committee,
2021-2024. LMS Nominations Committee,
2004-2011. LMS Education Secretary and Council Member
2023-Present. Director of the Bath Royal, Literary and Scientific Society (BRLSI),
2019-2023. SIAM Education Committee,
2021-2022. RAMP Steering Committee,
2020-2022. INI-IDP HE Committee ,
2010-Present. Parliamentary and Scientific Committee,
2018-2023. Royal Society Newton Fellowship Ctee.,
2016-2019. Chair of the UKMT, (now UKMT Board Cttee member),

2016-Present. European Maths Society Public Engagement Committee,
2014-2020. Dynamic Earth theme leader for the GW4+ NERC DTP,
2014-2022. LMS International Affairs Ctte,

**Current Editorships**

Lead editor: IMA Transactions
Associate Editor: Royal Society Open Science

**Postgraduate supervision**

PhD Students: 42 completed, 5 current, 15+ Post Doctoral Research Assistants. Over 40 MSc students, all on problems in industrial applied mathematics.

**Grants**

Principal Investigator on research grants totaling over £7M including a £1M EPSRC Critical mass grant on Complexity for 8 PDRAs (2004), a Marie-Curie ITN Grant on PDES for 39 PhD students (2009), a NERC grant for 4 PDRAs on moving mesh methods (2015), £3.5M EPSRC Programme Grant (Maths for Deep Learning 2022), 5 Innovate UK A4I Grants (2023-2025)

Principal investigator on public understanding of science grants totaling over £200k including Bath Taps Into Science and the 2010 Royal Society Summer Exhibition.

**Invited presentations and conference organisation**

Frequent key note talks to meetings all over the world. Recent highlights include:

Keynote speaker on mathematical modelling, ICIAM (Vancouver), July 2011
Invited speaker on non-smooth dynamics, Tokyo, July 2012
Invited speaker, ITN meeting on PDEs, Jerusalem, September 2012
Plenary speaker Maths for Planet Earth, Melbourne, July 2013
Keynote speaker at the 100th Industrial Study Group, Oxford, April 2014
Plenary Speaker at CAIMS, Waterloo, Canada, June 2015
Seeley Fellow prize lecture on Climate Change, Auckland, August, 2015
Keynote speaker on the Nordic conference on maths in industry, September 2016
Keynote speaker at the New York Museum of Maths, June 2017
Organiser and speaker at the Banff workshop on Moving Mesh Methods, June 2018
Two week visiting Professor/lectureship at the Fields Institute, November 2018
Keynote speaker at the Heidelberg Luareate Forum, September, 2019
Principal research visitor at the INI programme in numerical analysis, July-Dec, 2019.
Keynote speaker at the JMM meeting, Denver, January 2020
INI Programme on Deep Learning, July-Dec 2021
Keynote speaker at the Royal Society RAMP final meeting, June 2022
Invited speaker as the FoCM meeting, Paris, June 2023.
Invited speaker at the Japanese Meeting on Scientific Machine Learning, March 2024
Keynote speaker at PIMS confernce on Scientific Machine Learning, Seattle, June 2025

I have been the lead organiser, or on the executive committee of many conferences, including:

2015 CliMathNet (100 particpants), 2016 Moving Mesh Methods (100 participants), 2017 SciCADE (400 participants), 2018 ESGI (80 participants), 2019 BAMC (350 participants), 2020 Mathematical Models for Weather and Climate Prediction (160 participants), 2020+ numerous virtual study groups, 2022 ICMS workshop on adaptive mesh methods, 2023 ESGI (80 participants), 2023 BMC, as well as many Maths4DL conferences

I have been lead organiser of 3 ESGI study groups and 15 Virtual study groups. I have participated in study groups in UK, Ireland, Canada, Holland and Japan.

**Books and significant reports**

C. Budd and C. Sangwin, *Mathematics Galore!*, (2001), OUP. ISBN 0-19-850769-0
M. di Bernardo, C. Budd, A. Champneys and P. Kowalczyk, *Piecewise-smooth dynamical systems: theory and applications*, Applied Mathematical Sciences, 163, Springer, (2009), ISBN 978-1-84628-039-9.
C. Vorderman, R. Porkess, C. Budd, R. Dunne, *A Mathematics education for all our young people* (the *Vorderman Report*), (2011).
C. Budd, A. Champneys, M. Freiberger, P. Glendinning, S. Humble, R. Thomas, A. Wadee, *50 visions of mathematics*, OUP, (2014), ISBN: 9780198701811
C. Budd, *Climate, Chaos and Covid; how mathematical models describe the universe*, (2023), World Scientific Press, ISBN: 978-1-80061-304-1

**Selected Academic Journal Papers. A * indicates over 200 citations**

Over 140 published papers, **h-index 41**

C. Budd & J. Norbury, 'Semilinear elliptic equations and supercritical growth', J. Diff. Eqns., **68**, (1987), 169–197.
C. Budd, A. Friedman, J. McLeod & A. Wheeler, 'The space charge problem', SIAM J. Appl. Math., **50**, (1990), 181–198.
T. Murdoch & C. Budd, 'Convergent and spurious solutions of nonlinear elliptic equations', IMA J. Num. Anal., **12**, (1992), 365–386.
C. Budd, J. Dold & A. Stuart, 'Blow-up in a partial differential equation with constrained first integral', SIAM J. Appl. Math., **53**, (1993), 718–742.
*C. Budd, C. Harris & J. Vickers, 'Dynamic models for the competition between two companies seeking a monopoly', Rev. Economic Studies **60**, (1993), 543–573.
*C.Budd & F. Dux, 'Chattering and related behaviour in impacting oscillators', Phil. Trans. Roy. Soc. **347**, (1994), 365–389.
C. Budd, K.A. Cliffe & F. Dux, 'The effect of frequency and clearance variations on a single degree of freedom impact oscillator', J. Sound and Vibration, **184**, (1995), 475–502
*C. Budd, W. Huang & R. Russell, 'Moving mesh methods for problems with blow-up', SIAM J. Sci. Comp., **17**, (1996), 305–327.
C. Budd, J. Dold & V. Galaktionov, 'Self-similar blow-up for a quasilinear parabolic equation with gradient diffusion and exponential source', Advances in Differential Equations, **2**, (1997), 85–124.
C. Budd, V. Galaktionov and J. Chen, 'Focusing blow-up for quasilinear parabolic equations', Proc. Roy. Soc. Edinb., **128A**, (1998), 965–992.
C. Budd, G. W. Hunt, and M. A. Peletier, 'Self-similar Fold Evolution under Prescribed End-Shortening', Journal of Mathematical Geology, **31**, (1999), 989–1005.
C.J. Budd and A. Iserles, 'Geometric integration - the numerical solution of differential equations on manifolds', Phil. Trans. Roy. Soc. Lond. A., **357**, (1999), 945–956.
C.J. Budd, S. Chen and R. Russell, 'New self-similar solutions of the nonlinear Schrödinger equation, with moving mesh computations', J. Comp. Phys., **152**, (1999), 756–789.
C.J. Budd and M. Peletier, 'Approximate self-similarity in models of rock folding', SIAM J. Appl. Math., **60**, (2000), 990-1016

*G.W. Hunt, M.A. Peletier, A.R.Champneys, A. R., P. D. Woods, M.A. Wadee, C.J. Budd and G.L. Lord, G. L., 'Cellular Buckling in Long Structures', Nonlinear Dynamics', **21**, (2000), 3–29

M. di Bernardo, C.J. Budd and A. Champneys, 'Normal form maps for grazing bifurcations in $n$-dimensional piecewise-smooth dynamical systems'. Phys. D 160 (2001), 222–254.

M. di Bernardo, C.J. Budd and A. Champneys, 'Grazing and border collision in piecewise smooth systems: a unified analytical framework', Phys. Rev. Lett., Phys. Rev. Lett. 86, (2001), 2553–2556.

C.J. Budd and J. Wilson, 'Bogdanov-Takens points and Silnikov homoclinicity in a simple power system model of voltage collapse', IEEE Trans. on Circuits and Systems, **49**, (2002)

C.J. Budd, V.A.Galaktionov and J.F. Williams, 'Self-similar blow-up in higher order semilinear parabolic equations', SIAM J Appl. Math **64** (5) (2004), 1775–1809.

S. Blanes and C.J. Budd, *Explicit Adaptive SYmplectic (EASY) integrators: a scaling invariant generalisation of the Levi-Civita and KS regularizations*, Celest. Mech. Dyn. Astr. **89** (4), (2004), 383–405.

C.J.Budd, R. Carretero and R.D. Russell, ' Precise computations of chemotactic collapse using moving mesh methods', J. Comp. Phys. 202 (2), (2005) 463–487.

*M. di Bernardo, C.J. Budd, A.R. Champneys, P. Kowalczyk, A.B. Nordmark, G. Olivar and P.T. Piiroinen, *Bifurcations in nonsmooth dynamical systems*, SIAM Review, **50**, (2008), 629–701.

*C. J. Budd, W-Z Huang and R.D.R. Russell, *Adaptivity with moving grids*, Acta Numerica, (2009), 1–131.

C.J. Budd and A.D.C. Hill, *A comparison of models and methods for the microwave heating of moist foodstuffs*, Int. J. Heat and Mass Transfer, **54**, (2011), 807–817.

C.J. Budd and V.A. Galaktionov, *On self-similar blow-up in evolution equations of Monge-Ampére type*, IMA J. Appl. Math., (2011), 1-41.

T.J. Dodwell, M.A. Peletier, C.J. Budd and G.W. Hunt, *Self similar voiding solutions of a single layered model of folding rocks*, (2012), SIAM J. Appl. Math, **72**, 444-463.

M.A. Freitag, Nichols, N. K. and Budd, C. J., 2013. *Resolution of sharp fronts in the presence of model error in variational data assimilation.*, Quarterly Journal of the Royal Meteorological Society, **139** (672), (2013), 742-757.

Budd, C. J., Cullen, M. J. P. and Walsh, E. J., *Monge Ampere based moving mesh methods for numerical weather prediction, with applications to the Eady problem.* Journal of Computational Physics, **236**, (2013), 247-270.

P.A. Browne, C.J. Budd, M. Cullen, C. Piccolo, *Fast three dimensional r-adaptive mesh redistribution*, (2014), J. Comp. Phys **275**, 174–196.

K. Mora, C. Budd, P. Glendinning and P. Keogh, *Non-smooth Hopf-type bifurcations arising from impact/friction contact events in rotating machinery*, (2014), Proc. Roy. Soc., Lond. A

C.J. Budd, J.W. Dold and V. A. Galaktionov, *Global Blow-Up for a Semilinear Heat Equation on a Subspace* , (2015), Proc Roy. Soc. Edinburgh **145**, 893–923.

H. Weller, P. Browne, C. J. Budd, M. Cullen, *Mesh adaptation on the sphere using optimal transport and the numerical solution of a MongeAmpre type equation*, (2016), J. Comp. Phys. , **308**, 102–123.

C. J. Budd, A. N. Chakhchoukh, T. Dodwell, R. Kuske, *Chevron folding patterns and heteroclinic orbits*, (2016), Physica D, **330**, 32–46.
C.J. Budd, M. Cullen and C. Piccolo, *Improving weather forecasting accuracy by using r-adaptive methods coupled to data assimilation algorithms*, (2016) in: UK Success Stories in Industrial Mathematic, ed. P. Aston, A. Mulholland and K. Tant, 11–18, Springer.
C. Bowen, C. Budd, N. McCullen, R Bouamrane and M. Aouaichia, *Understanding the anomalous frequency responses of composite materials using very large random resistor-capacitor networks*, European Physical Journal B, (2017)
A. McRae, C. Cotter and C. Budd, *Optimal transport methods for finite element calculations for moving meshes on the sphere*,, SIAM J. Sci. Comput., **40**, (2018)
C. Budd, A. McRae and C. Cotter, *The scaling and regularity of r-adaptive meshes on the sphere*, (2019), J. Comp. Phys., **375**, 540–564.
S. Cook, C. Budd, A. Hill, T. Melvin, *Error estimates for semi-Lagrangian finite difference methods applied to Bergers' equation in one dimension*, (2019), Applied Numerical Mathematics, **145**, 261–282.
C. Budd, S. Cook and T. Melvin, *The Moving Mesh SISL method*, J. Comp. Phys., (2019), **393**, 484–502.
P.Amodio, C. Budd, O. Koch, V. Rottschfer, G. Settanni, E. Weinmller, *Near critical, self-similar, blow-up solutions of the generalised Kortewegde Vries equation: Asymptotics and computations*, (2020), Physica D, **401**, 132-179
C. Budd, D. Jackson and M. Griffith, *Stable Extension of the Unified Model into the Mesosphere and Lower Thermosphere* , J. of Space Weather and Space Climate, (2020)
K. S. Morupisi and C J Budd, *An analysis of the periodically forced PP04 climate model, using the theory of non-smooth dynamical systems*, IMAJAM, **86**, (2021), 76–120.
J Enright, E M Hill, H B Stage, K J Bolton, E J Nixon, E L Fairbanks, M L Tang, E Brooks-Pollock, L Dyson, C J Budd, R B Hoyle, L Schewe, J R Gog, M J Tildesley *SARS-CoV-2 infection in UK university students: lessons from SeptemberDecember 2020 and modelling insights for future student return*, Royal Society Open Science **8**, (2021),
C. Budd, K. Calvert and S. Tickle, *Assessing risk in the retail environment during the COVID-19 pandemic*, Proc Roy Soc. Open Science, (2021)
C. Budd, C. Griffiths and R. Kuske, *Dynamic tipping in the non-smooth Stommel-box model, with fast oscillatory forcing*, Physica D: Nonlinear Phenomena, **432**, (2022),
C.J. Budd and K.S. Morupisi, *Grazing bifurcations and transitions between periodic states of the PP04 model for the glacial cycle*, IMAJAM **87**, (2022), 462–491.
EA Murphy, B. Ehrhardt, C L Gregson, OA von Arx, A Hartley, MR Whitehouse, MS Thomas, G Stenhouse, TJS Chesser, CJ Budd, HS Gill *Machine learning outperforms clinical experts in classification of hip fractures*, Nature Scientific reports **12**, (2022).
T. Babasola and C. Budd, *Mathematical analysis of a time-delayed model for cocoa yield*, IMAJAM, **88**, (2023), 702-734.
C. Budd and R. Kuske, *Dynamic tipping and cyclic folds, in a one-dimensional non-smooth dynamical system linked to climate models* , Physica D, **347**, (2024)
B. Krauskopf, A. Keane, C Budd, *Conceptual climate modelling*, Physica D: Nonlinear Phenomena, **468**, (2024)
C. Budd, *Chaos: From celestial mechanics to climate*, Journal of Physics: Conference Series, **2877**, (2024)

C.J. Morcrette, T. Cave, H. Reid, J.D. da Silva Rodrigues, T. Deveney, L. Kreusser, K. Van Weverberg, C. Budd, *Scale-aware parameterization of cloud fraction and condensate for a global atmospheric model machine-learnt from coarse-grained kilometer-scale simulations*, JAMES **17**, (2025)
S. Appella, C Budd, T Pryer, *Computationally efficient r adaptive graded meshes over non-convex domains*, Computers and Mathematics with Applications **192**, 240-258, (2025)
T. Deveney, J. Stanczuk, L. Kreusser, C. Budd, C.B. Schönlieb, *Closing the ODE SDE gap in score-based diffusion models through the FokkerPlanck equation*, Philosophical Transactions A 383 (2298), (2025)
J. Rowbottom, G. Maierhofer, T. Deveney, E. Mller, A. Paganini, K. Schratz, C. Budd, *G-Adaptivity: optimised graph-based mesh relocation for finite element methods*, 42nd International Conference on Machine Learning, (2025)
C. Liu, C. Budd, C.B. Schönlieb, *Inverse evolution data augmentation for neural PDE solvers*, Philosophical Transactions A 383 (2298), (2025)

C. Liu, Y. Li, Z. Deng, C. Budd, C.B. Schönlieb,*Conservation-preserved Fourier Neural Operator through Adaptive Correction*, arXiv preprint arXiv:2505.24579, (2025) submitted
C. Liu, D. Murari, C. Budd, L. Liu, C.B. Schönlieb, *Enhancing fourier neural operators with local spatial features*, arXiv preprint arXiv:2503.17797, (2025), submitted