Patrick Sanan

CONTACT
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patricksanan.org

CITIZENSHIP Ireland, United States
RESIDENCY   Switzerland (Zurich, C)
LANGUAGES   English (native), German (B2)

PROFILE
Software engineer with background in applied mathematics, computational science, and scientific software.

TECHNICAL SKILLS
very experienced: C, C++, Python, SQL, Git, shell scripting, MPI, MATLAB, LaTeX, SuperCollider, Processing
significant experience: Fortran, CUDA, Mathematica, Julia, Eigen

EDUCATION

Ph.D. Applied and Computational Mathematics, California Institute of Technology (Caltech) 2013

MusM Electroacoustic Music Composition, University of Manchester 2007
With Distinction

B.S. Aerospace Engineering
B.A. Math-Applied Science, University of California, San Diego (UCSD) 2006
Minor: Music
Summa Cum Laude

PROFESSIONAL EXPERIENCE

Software Engineer, Google, Zurich June 20, 2022–Present
- User protection, production systems, applied ML, data analysis, statistics

Computational Mathematician, Argonne National Laboratory November 2021–June 17, 2022
Remote contractor
Laboratory for Applied Mathematics, Numerical Software, and Statistics

Scientific Collaborator, **Lecturer**, ETH Zurich November 2021–June 17, 2022
PASC GPU4GEO Software Development Project
Geophysical Fluid Dynamics Group
PI: Paul J. Tackley

Postdoctoral Researcher, **Lecturer**, ETH Zurich July 2021–October 2021
PASC GPU4GEO Software Development Project
Geophysical Fluid Dynamics Group
PI: Paul J. Tackley

Postdoctoral Researcher, **Lecturer**, ETH Zurich November 2017–June 2021
PASC STAGBL Software Development Project
Geophysical Fluid Dynamics Group
PI: Paul J. Tackley
- Led development on STAGBL, DMStag within PETSC, and SCIATH

- Collaborated on several publications on Earth and Planetary science, as well as on solvers.

Postdoctoral Researcher, ETH Zurich   October 2017
SALVUS Project
[Seismology and Wave Physics Group]

- Performed initial investigations into accelerating use of PETSc's DMPlex within SALVUS.

Postdoctoral Researcher, Universitá della Svizzera italiana (USI)   June 2014–September 2017
[PASC GeoPC Co-Design Project]
PI: Paul J. Tackley (ETH Zurich)
Advisors: Olaf Schenk (USI), Dave A. May (ETH Zurich)

- Researched and implemented large-scale, parallel, communication-avoiding and GPU-accelerated operators and multigrid smoothers for large-scale Stokes flow.

Givens Scholar, [MCS Division, Argonne National Laboratory]   Summer 2013
Supervisor: [Jed Brown]

- Investigated multiscale integrators in PETSc

Software Engineering Intern, [Rhythm and Hues Studios]   Summer 2012
El Segundo, CA, United States

- Worked with the software engineering team at an award-winning (Babe, Life of Pi, etc.) graphics studio.
- Researched and implemented a surface parameterization algorithm minimizing an elastic energy under inversion constraints.

Teaching Assistant and Instructor, Caltech   Fall–Spring 2008-2013

Grader and Tutor, UCSD   Fall 2004, Summer 2005

Mechanical Engineering Intern, General Atomics Lynx Systems   Summer 2004
San Diego, CA, United States

- Performed CAD and analysis for synthetic aperture radar.

Sales Clerk, Long Drugs   part time 2000-2001
Walnut Creek, CA, United States

PUBLICATIONS
- Patrick Sanan, Dave A. May, Richard T. Mills, and Boris J. P. Kaus. DMStag: Staggered, structured grids for PETSc. *Journal of Open Source Software*, 7(79):4531, 2022. doi:[10.21105/joss.04531]. URL [https://doi.org/10.21105/joss.04531]

- Casper Pranger, Patrick Sanan, David May, Laetitia Le Pourhiet, and Alice-Agnes Gabriel. Rate and state friction as a spatially regularized transient viscous flow law. *Earth and Space Science Open Archive*, page 55, 2021. doi:[10.1002/essoar.10508569.1]. URL [https://doi.org/10.1002/essoar.10508569.1]

- Dan J. Bower, Kaustubh Hakim, Paolo A. Sossi, and Patrick Sanan. Retention of water in terrestrial magma oceans and carbon-rich early atmospheres, 2021

- Mark Adams, Satish Balay, Oana Marin, Lois Curfman McInnes, Richard Tran Mills, Todd Munson, Hong Zhang, Junchao Zhang, Jed Brown, Victor Eijkhout, Jacob Faibussowitsch, Matthew Knepley, Fande Kong, Scott Kruger, Patrick Sanan, Barry F. Smith, and Hong Zhang. The PETSc community is the infrastructure, 2022

- Weidong Sun, Charles H. Langmuir, Neil M. Ribe, Lipeng Zhang, Saijun Sun, He Li, Congying Li, Weiming Fan, Paul J. Tackley, and Patrick Sanan. Plume-ridge interaction induced migration of the Hawaiian-Emperor seamounts. *Science Bulletin*, 2021. ISSN 2095-9273. doi:[10.1016/j.scib.2021.04.028]

- D. P. Bolrão, M. D. Ballmer, A. Morison, A. B. Rozel, P. Sanan, S. Labrosse, and P. J. Tackley. Timescales of chemical equilibrium between the convecting solid mantle and over- and underlying magma oceans. *Solid Earth*, 12(2):421–437, 2021. doi:[10.5194/se-12-421-2021]. URL [https://se.copernicus.org/articles/12/421/2021/]

- Tim Lichtenberg, Dan J. Bower, Mark Hammond, Ryan Boukrouche, Patrick Sanan, Shang-Min Tsai, and Raymond T. Pierrehumbert. Vertically resolved magma ocean–protoatmosphere evolution: H2, H2O, CO2, CH4, CO, O2, and N2 as primary absorbers. *Journal of Geophysical Research: Planets*, 126(2), 2021. doi:https://doi.org/10.1029/2020JE006711

- Hannah Morgan, Patrick Sanan, Matthew G. Knepley, and Richard Mills. Understanding performance variability in standard and pipelined parallel Krylov solvers. *The International Journal of High Performance Computing Applications*, 2020. doi:10.1177/1094342020966835

- Neil M. Ribe, Paul J. Tackley, and Patrick Sanan. The strength of the Iceland plume: A geodynamical scaling approach. *Earth and Planetary Science Letters*, 551:116570, 2020. doi:10.1016/j.epsl.2020.116570

- Patrick Sanan, Dave A. May, Matthias Bollhöfer, and Olaf Schenk. Pragmatic solvers for 3D Stokes and elasticity problems with heterogeneous coefficients: Evaluating modern incomplete LDL^T preconditioners. *Solid Earth*, 11(6):2031–2045, 2020. doi:10.5194/se-11-2031-2020. URL https://se.copernicus.org/articles/11/2031/2020/

- Dan J. Bower, Daniel Kitzmann, Aaron S. Wolf, Patrick Sanan, Caroline Dorn, and Apurva V. Oza. Linking the evolution of terrestrial interiors and an early outgassed atmosphere to astrophysical observations. *A&A*, 631:A103, 2019. doi:10.1051/0004-6361/201935710

- Charitra Jain, Antoine B. Rozel, Paul J. Tackley, Patrick Sanan, and Taras V. Gerya. Growing primordial continental crust self-consistently in global mantle convection models. *Gondwana Research*, 2019. ISSN 1342-937X. doi:https://doi.org/10.1016/j.gr.2019.03.015

- Scott Kruger, Patrick Sanan, and Barry F. Smith. PETSc developers manual. Technical Report ANL-18/18 Rev 3.10, Argonne National Laboratory, 2018. URL https://www.mcs.anl.gov/petsc/developers/developers.pdf

- Simplice Donfack, Patrick Sanan, Olaf Schenk, Bram Reps, and Wim Vanroose. A high arithmetic intensity Krylov subspace method based on stencil compiler programs. In *High Performance Computing in Science and Engineering*, pages 1–18. Springer International Publishing, 2018. doi:10.1007/978-3-319-97136-0_1

- Dan J. Bower, Patrick Sanan, and Aaron S. Wolf. Numerical solution of a non-linear conservation law applicable to the interior dynamics of partially molten planets. *Physics of the Earth and Planetary Interiors*, 274(Supplement C):49–62, 2018. doi:10.1016/j.pepi.2017.11.004

- Satish Balay, Shrirang Abhyankar, Mark F. Adams, Jed Brown, Peter Brune, Kris Buschelman, Lisandro Dalcin, Victor Eijkhout, Dinesh Kaushik, Matthew G. Knepley, Dave A. May, Lois Curfman McInnes, William D. Gropp, Karl Rupp, Patrick Sanan, Barry F. Smith, Stefano Zampini, Hong Zhang, and Hong Zhang. PETSc users manual. Technical Report ANL-95/11 - Revision 3.8, Argonne National Laboratory, 2017

- Dave A. May, Patrick Sanan, Karl Rupp, Matthew G. Knepley, and Barry F. Smith. Extreme-scale multigrid components within PETSc. In *PASC '16: Proceedings of the Platform for Advanced Scientific Computing Conference*, 2016. doi:10.1145/2929908.2929913

- P. Sanan, S. M. Schnepp, and D. A. May. Pipelined, flexible Krylov subspace methods. *SIAM Journal on Scientific Computing*, 38(5):C441–C470, 2016. doi:10.1137/15M1049130

- Hannah Morgan, Matthew G. Knepley, Patrick Sanan, and L. Ridgway Scott. A stochastic performance model for pipelined Krylov methods. *Concurrency and Computation: Practice and Experience*, 28(18):4532–4542, 2016. doi:10.1002/cpe.3820

- Patrick Sanan. *Geometric Elasticity for Graphics, Simulation, and Computation*. PhD thesis, California Institute of Technology, 2014. URL http://resolver.caltech.edu/CaltechTHESIS:12052013-121547860

- Isaac Chao, Ulrich Pinkall, Patrick Sanan, and Peter Schröder. A simple geometric model for elastic deformations. In *ACM SIGGRAPH 2010 Papers*, SIGGRAPH '10, pages 38:1–38:6, New York, NY, USA, 2010. ACM. ISBN 978-1-4503-0210-4. doi:10.1145/1833349.1778775

SELECTED
TALKS

- "Performance-Portable Staggered Grid Stokes Flow Solves with StagBL and MARS", SIAM CSE (virtual), March 4, 2021.

- "Staggered Grid Abstractions for Scalable Solvers", FOALAB Group Meeting, University of Oxford, October 18, 2019.

- "STAGYY and STAGBL: Developing Tools for Large-Scale Geodynamic Simulations Using Staggered-Grid Discretisation on Hybrid Architectures", PASC 19 Conference, ETH Zurich, Zurich, Switzerland, June 12-14, 2019.

- "Modern Solvers for Global Mantle Convection: STAGYY with STAGBL" (PICO presentation), EGU General Assembly, Vienna, Austria, April 8-12, 2019.

- "DMSTAG: A Staggered-grid Abstraction for PETSC", PETSC Users' Meeting, Imperial College, London, United Kingdom, June 4-6, 2018.

- "Hybrid Operators and Composable Software within Lithospheric Dynamic Simulation", SIAM Conference on Parallel Processing for Scientific Computing, Tokyo, Japan, March 7-10, 2018.

- "STAGBL: A Scalable, Portable, High-Performance Discretization and Solver Layer for Geodynamic Simulation", PASC 18 Conference, Basel, Switzerland, July 2-4, 2018.

- "GeoPC: Composable Solvers for Geophysics on Modern Architectures", PASC 17 Conference, Lugano, Switzerland, June 26-28, 2017. [slides online]

- "Preconditioners for Stokes Flow with Highly Heterogeneous Viscosity Structure: Saddle-Point Smoothing Via Local Incomplete Factorization", SIAM CSE, Atlanta, United States, February 27-March 3, 2016.

- "Robust Multigrid Solvers For Highly Heterogeneous Stokes Flow," Swiss Geoscience Meeting, Geneva, Switzerland, November 18-19, 2016.

- "Robust Multigrid Solvers for Geodynamics," German-Swiss Geodynamics Workshop, Lichtenfels, Germany, September 11-14, 2016.

- "Extreme-scale Multigrid Components within PETSc", PETSc Users Meeting, Vienna, Austria, June 28-30, 2016.

- "Extreme-scale Multigrid Components within PETSc", ACM/PASC16 conference, Lausanne, Switzerland, June 8-10, 2016.[video online]

- "Accelerating Parallel Multilevel Solvers for Stokes Flow with Highly Heterogeneous Viscosity Structure: Localized Incomplete LDL^T Smoothers and GPUs", EGU General Assembly, Vienna, Austria, April 17-22, 2016.

- "Co-designing algorithms: Pipelined, Flexible Krylov Subspace Methods and Accelerated Subdomain Solves", SeisMIC, Technical University of Ostrava, Czech Republic, February 5, 2016.

- "Co-designing algorithms: Pipelined, Flexible Krylov Subspace Methods and Accelerated Subdomain Solves", Computing Sciences Seminar, Lawrence Berkeley Lab, January 12, 2016.

- "Pipelined, Flexible Krylov Subspace Methods and Accelerated Subdomain Smoothing: Attacks on aggressive nested preconditioners for challenging geophysical Stokes flow problems"[minisymposium talk], SIAM Conference on Applied Linear Algebra, Atlanta, Georgia, USA, October 26-30, 2015.

- "Towards Aggressive, Accelerated Multigrid Smoothing"[invited talk], ASE Seminar, University of Tokyo, Tokyo, Japan, October 16, 2015.

- "Pipelined, Flexible Krylov Subspace Methods"[invited talk], IWACOM-III, Tokyo, Japan, October 12-14, 2015.

- "Using Julia on a Cray Supercomputer"[lightning talk], Juliacon 2015, MIT, Boston, Massachusetts, USA, June 24-27, 2015. [video online]

TEACHING	**651-4144-00L Introduction to Finite Element Modelling in Geosciences**	ETH Zurich
	Lecturer [website]	Summer 2018, 2019, 2020, 2021
	Instructor [website]	Summer 2017
	Assistant [website]	Summer 2016
	HPC Libraries	CSCS Summer School
	Instructor [materials online]	July 27, 2017
	Instructor [materials online]	July 28, 2016
	Instructor [materials online]	August 30, 2015
	Software Engineering For Computational Science	USI
	Instructor [materials online]	Fall 2015
	ACM 11: Introduction to Mathematica and MATLAB	Caltech
	Instructor [materials online]	Spring 2013
	ACM 11, 95/100abc, 101abc, 106abc, 118	Caltech
	Teaching Assistant	Fall–Spring 2008-2013
	MAE 3: Introduction to Design and Graphics	UCSD
	Tutor	Fall 2004
	Additional Short Tutorials [See patricksanan.org]	

EDUCATIONAL HONORS	2007-2008 Kaplun Graduate Fellowship, Caltech ACM
	2006-2007 Tony Thornley Scholarship (full Master's scholarship)
	2006 Highest Academic Achievement Award in Aerospace Engineering, UCSD
	2006 John E. Starlett Memorial Scholarship Award, UCSD
	Tau Beta Pi, Phi Beta Kappa
	2005 Dean's Award for Excellence, UCSD: Mathematics
	Jacobs Engineering Scholar, Jacobs School of Engineering, UCSD (4-year full scholarship)
	Regents Scholar, UCSD

REFERENCES	Available on request.