

Ben S. Southworth

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Jan. 2023

Education

Dec. 2017	PhD Applied Mathematics	University of Colorado at Boulder
May 2015	MSc Applied Mathematics	University of Colorado at Boulder
May 2013	AB Mathematics	Dartmouth College

Research Interests

Algebraic multigrid: convergence theory, nonsymmetric linear systems
Preconditioners: block preconditioners, space-time discretizations, hyperbolic PDEs
Radiative transport: parallel algorithms, high-order meshes, heterogeneous mediums
Partitioned time integration, parallel-in-time methods
Numerical PDEs: finite-elements, Newton methods, Krylov methods

Research Experience

2022 – present	Scientist II Los Alamos National Laboratory
2020 – 2022	Nicholas Metropolis Postdoctoral Fellow Los Alamos National Laboratory
2018 – 2020	Postdoctoral Research Associate University of Colorado Department of Applied Mathematics Advisor: Tom Manteuffel
2015 – 2017	Research Assistant University of Colorado Department of Applied Mathematics Advisor: Tom Manteuffel
2014 – 2017	Research Assistant Laboratory for Atmospheric and Space Physics Advisor: Sascha Kempf

Awards

2022-2025	Co-I – <i>Advancing the Mission: Sparse View Dynamic Tomographic Reconstruction for 3D Code Validation</i> (PI: Marc Klasky) Los Alamos National Laboratory Directed Research (20230068DR) Three years, \$1.74M/year
2021-2024	Co-PI – <i>High-order Implicit-Explicit Time Integration for Radiation Transport and Coupled Multiphysics Problems</i> (PI: HyeongKae Park) Los Alamos National Laboratory Exploratory Research (20220174ER) Three years, \$325K/year
2021-2022	PI – <i>Modeling for Enceladus Plume and Jets</i> JPL, Interagency agreement One year, \$27K
2021-2024	Co-author & Collaborator – <i>Parallel Space-Time Solvers for Systems of Partial Differential Equations</i> (PI: Jacob Schroder, UNM) NSF Computational Mathematics (2110917)

2020	Co-PI – <i>Fast solvers for Magnetically Confined Plasma</i> U.S. Department of Energy, Subcontract One year, \$60K
2020	PI – <i>Numerical methods for Thermal Radiative Transfer</i> U.S. Department of Energy, Subcontract One year, \$65K
2019	NSF International Travel Award (<i>ICIAM</i>)
2018	Co-PI – <i>Algebraic Multigrid for Thermal Radiative Transfer</i> U.S. Department of Energy, Subcontract B627942 One year, \$70K
2018	NSF Travel Award (<i>25th Domain Decomposition Conference</i>)
2018	SIAM Travel Award (<i>SIAM Annual Meeting</i>)
2017	Jülich Supercomputing Travel Grant (<i>6th Parallel-in-time Workshop</i>)
2016	SIAM Student Travel Award (<i>SIAM CSE</i>)
2015 – 2017	National Defense Science and Engineering Graduate Fellow
2013 – 2015	University of Colorado Boulder Peaks Fellowship Recipient
2012	P.K. Richter and E.E. Cook Memorial Research Fund Recipient
2012	Neukom Undergraduate Research Scholar
2009 – 2013	Dartmouth College Furstenberg Memorial Scholar
2009 – 2013	La Plata Electric Association Scholar
2009 – 2013	Aegion Family Scholar
2009 – 2013	Robert C. Byrd Honors Scholar

Other:

Chose name “Summit” for University of Colorado super computer (2016)

Invited Research Visits and Review Panels

06/09/19 – 06/14/19	NASA , Solar System Workings Review Panel
05/20/19 – 05/24/19	University of Waterloo , Professor Sander Rhebergen

In Review

- [7] M. Anghel, T. Sant, Z. Parker, and **B. S. Southworth**. Efficient modal analysis of complex engineered structures using extreme reduced order modeling. *LANL Weapons Engineering Symposium Journal (in review)*, 2023.
- [6] G. A. Wimmer, **B. S. Southworth**, T. J. Gregory, and X. Tang. A fast algebraic multigrid solver and accurate discretization for highly anisotropic heat flux I: Open field lines. *SIAM J. Sci. Comput. (in review)*, 2023.
- [5] T. Buvoli and **B. S. Southworth**. Additive polynomial time integrators, part I: Framework and fully-implicit-explicit (FIMEX) collocation methods. *SIAM J. Sci. Comput. (in review)*, 2022.
- [4] M. Holec, B. Zhu, I Joseph, C. J Vogl, **B. S. Southworth**, A. Campos, A. M. Dimits, and W. E. Pazner. Arbitrary order energy and enstrophy conserving finite element methods for 2d incompressible fluid dynamics and drift-reduced magnetohydrodynamics. *J. Comput. Phys. (in review)*, 2022.
- [3] V. S. Hurd, T. A. Nordheim, **B. S. Southworth**, M. E. Cameron, J. A. Sinclair, D. A. Patthoff, H. Lethcoe, E. C. Fayolle, and M. L. Cable. Enceladus landing site analysis for in-situ sampling missions. *The Planetary Science Journal (in review)*, 2022.
- [2] S. Rhebergen and **B. S. Southworth**. An algebraic preconditioner for the exactly divergence-free discontinuous Galerkin method for Stokes. *SMAI J. Comput. Math. (in review)*, 2022.
- [1] F. Danieli and **B. S. Southworth**. Space-time block preconditioning for incompressible resistive magnetohydrodynamics. *J. Comput. Phys. (in review)*, 2022.

*Asterisk denotes lead-author publication when authors are listed alphabetically. Underline indicates student author who I mentored on the project.

Publications

- [22] E. S. Martin, J. L. Whitten, S. A. Kattenhorn, G. C. Collins, **B. S. Southworth**, L. S. Wisler, and S. Prindle. Measurements of regolith thicknesses on Enceladus: Uncovering the record of plume activity. *Icarus*, 392:115369, 2023.
- [21] M. Sugiyama, J. B. Schroder, **B. S. Southworth**, and S. Friedhoff. Weighted relaxation for multigrid reduction in time. *Numerical Linear Algebra with Applications*, 30(1):e2465, 2023.
- [20] **B. S. Southworth**, O. Krzysik, and W. Pazner. Fast solution of fully implicit Runge–Kutta and discontinuous Galerkin in time for numerical PDEs, part II: Nonlinearities and DAEs. *SIAM Journal on Scientific Computing*, 44(2):A636–A663, 2022.
- [19] **B. S. Southworth**, O. Krzysik, W. Pazner, and H.D. Sterck. Fast solution of fully implicit Runge–Kutta and discontinuous Galerkin in time for numerical PDEs, part I: the linear setting. *SIAM Journal on Scientific Computing*, 44(1):A416–A443, 2022.
- [18] F. Danieli, **B. S. Southworth**, and A. J. Wathen. Space-time block preconditioning for incompressible flow. *SIAM Journal on Scientific Computing*, 44(1):A337–A363, 2022.
- [17] Hahne, J., **B. S. Southworth**, and S. Friedhoff. Asynchronous truncated multigrid-reduction-in-time (atmgrid). *SIAM J. Sci. Comput.* (accepted), 2022.
- [16] S. Friedhoff and **B. S. Southworth***. On “Optimal” h-Independent Convergence of Parareal and MGRIT using Runge–Kutta Time Integration. *Numer Linear Algebra Appl.*, 28(3), 2021.
- [15] **B. S. Southworth**, M. Holec, and T. S. Haut. Diffusion synthetic acceleration for heterogeneous domains, compatible with voids. *Nuclear Science and Engineering*, 195(2):119–136, 2021.
- [14] A. A. Sivas, **B. S. Southworth**, and S. Rhebergen. AIR algebraic multigrid for a space-time hybridizable discontinuous Galerkin discretization of advection (–diffusion). *SIAM Journal on Scientific Computing*, 43(5):A3393–A3416, 2021.
- [13] **B. S. Southworth**, A. A. Sivas, and S. Rhebergen. On fixed-point, krylov, and 2×2 block preconditioners. *SIAM J. Matrix Anal. Appl.*, 41(2):871–900, June 2020.
- [12] J. Hanophy, **B. S. Southworth**, R. Li, T. A. Manteuffel, and J. Morel. Parallel approximate ideal restriction multigrid for solving the S_n transport equations. *Nuclear Science and Engineering*, pages 1–20, June 2020.
- [11] A. Henthaler, **B. S. Southworth**, D. Nordsletten, O. Röhrle, R. D. Falgout, and J. B. Schroder. Multilevel Convergence Analysis of Multigrid Reduction in Time. *SIAM J. Sci. Comput.*, 42(2):A771–A796, Mar. 2020.
- [10] T. S. Haut, **B. S. Southworth**, V. Z. Tomov, and P. G. Maginot. A DSA Preconditioner for the S_N Transport Equations on High-order Curved Meshes. *SIAM J. Sci. Comput.*, 42(5):B1271–B1301, 2020.
- [9] T. A. Manteuffel, S. Munzenmaier, J. Ruge, and **B. S. Southworth***. Nonsymmetric Reduction-Based Algebraic Multigrid. *SIAM J. Sci. Comput.*, 41(5):S242–S268, Oct. 2019.
- [8] T. A. Manteuffel and **B. S. Southworth**. Convergence in Norm of Nonsymmetric Algebraic Multigrid. *SIAM J. Sci. Comput.*, 41(5):S269–S296, Oct. 2019.
- [7] **B. S. Southworth**. Necessary Conditions and Tight Two-level Convergence Bounds for Parareal and Multigrid Reduction in Time. *SIAM J. Matrix Anal. Appl.*, 40(2):564–608, May 2019.
- [6] T. S. Haut, P. G. Maginot, V. Z. Tomov, **B. S. Southworth**, T. A. Brunner, and T. S. Bailey. An Efficient Sweep-based Solver for the S_N Equations on High-order Meshes. *Nuclear Science and Engineering*, pages 1–14, Jan. 2019.
- [5] **B. S. Southworth**, S. Kempf, and J. N. Spitale. Surface Deposition of the Enceladus Plume and the Angle of Emissions. *Icarus*, 319:33–42, Jan. 2019.
- [4] T. A. Manteuffel, J. Ruge, and **B. S. Southworth***. Nonsymmetric Algebraic Multigrid Based on Local Approximate Ideal Restriction (ℓ AIR). *SIAM J. Sci. Comput.*, 40(6):A4105–A4130, Dec. 2018.
- [3] T. A. Manteuffel, L. N. Olson, J. B. Schroder, and **B. S. Southworth***. A Root-Node-Based Algebraic Multigrid Method. *Copper Mountain Special Section, SIAM J. Sci. Comput.*, 39(5), Nov. 2017.
- [2] **B. S. Southworth**, S. Kempf, and J. Schmidt. Modeling Europa’s Dust Plumes. *Geophysical Research Letters*, 42(24):10,541–10,548, Dec. 2015.
- [1] D. I. Wallace, **B. S. Southworth**, X. Shi, J. W. Chipman, and A. K. Githeko. A Comparison of Five Malaria Transmission Models: Benchmark Tests and Implications for Disease Control. *Malaria J*, 13:268, Jul. 2014.

Conference Proceedings and Technical Reports

- [7] M. Holec, **B. S. Southworth**, T. S. Haut, and B. C. Yee. Nonlinear diffusion synthetic acceleration of thermal radiative transfer. In *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, pages Pages 1304–1313, 2021.
- [6] B. C. Yee, S. S. Olivier, **B. S. Southworth**, M. Holec, and T. S. Haut. A new scheme for solving high-order dg discretizations of thermal radiative transfer using the variable eddington factor method. In *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, pages Pages 1314–1323, 2021.
- [5] **B. S. Southworth**, W. Mitchell, A. Hessenthaler, and F. Danieli. Tight two-level convergence of Linear Parareal and MGRIT: Extensions and Implications in Practice. In *Workshops on Parallel-in-Time Integration*, pages 1–31. Springer, 2020.
- [4] J. Hanophy, J. Morel, **B. S. Southworth**, T. A. Manteuffel, and R. Li. Performance of Parallel Approximate Ideal Restriction Multigrid for Transport Applications. In *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, 2019.
- [3] T. Imken, B. Sherwood, J. Elliott, A. Frick, K. McCoy, D. Oh, P. Kahn, A. Karapetian, R. Polit-Casillas, M. Cable, J. Lunine, S. Kempf, **B. S. Southworth**, S. Tucker, and J. H. Waite. Sylph—A Smallsat Probe Concept Engineered to Answer Europa’s Big Question. In *AIAA/USU Conference on Small Satellites*, Aug. 2016.
- [2] R. D. Falgout, T. A. Manteuffel, J. B. Schroder, and **B. S. Southworth***. Parallel-in-time for Moving Meshes. Technical Report No. LLNL-TR-681918, Lawrence Livermore National Lab (LLNL), Livermore, CA (United States), Feb. 2016.
- [1] B. Sherwood, J. Lunine, J. Elliott, T. Imken, M. Cable, S. Kempf, **B. S. Southworth**, S. Tucker, J. H. Waite, A. Frick, K. McCoy, A. Karapetian, R. Polit-Casillas, P. Kahn, D. Oh, and K. P. Hand. Sylph: life detection probe for a europa plume. 2016.

Seminars

- [6] **Fully Implicit Time Integration: Fast Iterative Solvers and Implicit-Explicit Schemes**. Informatics Seminar, Università della Svizzera italiana, Sep. 2021.
- [5] **On nonsymmetric AMG, block preconditioners, and applications in fluids and transport**. Los Alamos National Laboratory, Oct. 2019.
- [4] **On Nonsymmetric Algebraic Multigrid Solvers and Hyperbolic PDEs**. Applied Math Seminar, University of Waterloo, May 2019.
- [3] **Approximate Ideal Restriction (AIR): an Algebraic Multigrid Method for Nonsymmetric Linear Systems**. Lawrence Livermore National Laboratory, Physics Division, Apr. 2018.
- [2] **Nonsymmetric Algebraic Multigrid: Developments in Theory and in Practice**. Stanford Linear Algebra and Optimization Seminar, Feb. 2018.
- [1] **Locating and Detecting Europa’s Water Vapor Plumes**. Europa Science Series, Jet Propulsion Laboratory, CA, Mar. 2016.

Recent Conference Presentations

- [8] **A linear-algebra perspective on convergence of Parareal and MGRiT**. 9th Workshop on Parallel-in-Time Methods, Zoom, June 2020.
- [7] **Necessary and Sufficient Conditions for Convergence of Parareal and MGRiT, and Implications in Practice**. International Congress on Industrial and Applied Mathematics, Valencia, Spain, July 2019.
- [6] **Hyperbolic PDEs and Parallel-In-Time: A Revival in Reduction Methods**. 19th Copper Mountain Conference On Multigrid Methods, March 2019.
- [5] **Nonsymmetric Algebraic Multigrid and Approximate Ideal Restriction (AIR)**. SIAM Conference on Computational Science and Engineering, Tacoma, WA, March 2019.
- [4] **An Algebraic Perspective on Parallel-in-time Integration**. SIAM Annual Meeting, July 2018.
- [3] **Approximate Ideal Restriction: an Algebraic Multigrid Method for Nonsymmetric Linear Systems**. 25th International Domain Decomposition Conference, July 2018.
- [2] **Approximate Ideal Restriction: an Algebraic Multigrid Method for Nonsymmetric Linear Systems**. 15th Copper Mountain Conference on Iterative Methods, Copper, CO, Mar 2018.
- [1] **Solving Space-time Discretizations of the Wave Equation with Algebraic Multigrid**. 6th Workshop on Parallel-in-Time Methods, Monte Verità, Switzerland, Oct. 2017.

Teaching Experience

2018	Supervise summer PhD student , Joshua Hanophy, Texas A&M Lawrence Livermore National Lab
2013 – 2014	Math Tutor Buff Tutors
2013 – 2014	Teaching Assistant , Calculus I University of Colorado Department of Applied Mathematics
2009 – 2013	Studio Assistant/Instructor F.A. Davidson Ceramics Studio
2009 – 2012	Ski Coach Durango Winter Sports Foundation

Professional Service

2021 – present	Parallel-in-Time Workshop Scientific Committee
2014 – present	Dartmouth Alumni Admissions Interviewer
2015 – 2017	Colorado State Science and Engineering Fair Judge
2011 – 2013	Founder and Webmaster Dartmouth SIAM

Organized mini-symposia:

- Back to the Future IV: Developments in Parallel-in-Time Integration* (two sessions, co-organized with Stephanie Friedhoff). ICIAM, July 2019.
- Developments in Algebraic Multigrid for Nonsymmetric and Hyperbolic Problems* (one session, organizer). SIAM CSE, Feb. 2019.
- Scalable Parallel Multigrid Solvers* (two sessions, co-organized with Amanda Bienz). SIAM CSE, Feb. 2019.
- AMG for Non-Symmetric Systems* (one session, co-organized with Tom Manteuffel). Copper Mountain Conference On Iterative Methods, Mar. 2018.
- Taming the Beast: Broadening the Applicability of Algebraic Multigrid* (two sessions, organizer). SIAM CSE, Feb. 2017.

Referee/Reviewer for:

- SIAM Journal on Scientific Computing
- SIAM Journal on Numerical Analysis
- SIAM Journal on Matrix Analysis
- Journal of Computational Physics
- Numerical Linear Algebra with Applications
- Computers & Mathematics with Applications
- Numerical Algorithms
- Journal of Numerical Analysis, Industrial and Applied Mathematics

Professional Memberships:

- Society for Industrial and Applied Mathematics

Skills

Coding languages:	C/C++, Python, Matlab
Parallel frameworks:	MPI, OpenMP
Developer tools:	Git, Docker, HDF5, PDB, TotalView
Personal skills:	Strong public speaker, organizer, and manager

Software Development

Developer:

PyAMG: Algebraic Multigrid Solvers in Python

– <https://github.com/pyamg/pyamg>

Parallel C++ libraries to construct space-time discretizations of PDEs

– <https://github.com/bensworth/SpaceTime-Matrices>

– <https://github.com/bensworth/SpaceTime-FiniteDifference>

OpenMP/MPI parallel C++ software for simulating dust plumes

– https://github.com/bensworth/moon_jets

– Software used for multiple NASA/ESA missions and proposals

Contributor:

hypre: High Performance Preconditioners

– <https://github.com/hypre-space/hypre>

MFEM Finite Element Discretization Library

– <https://github.com/mfem/mfem/>