

Alper Altuntas

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Summary

Senior software engineer at NSF NCAR specializing in large-scale, physics-based climate and ocean simulation. Working at the intersection of high-performance computing, scientific software, and formal methods to build, modernize, and accelerate production software systems that are scalable, reliable, and reproducible.

Experience

National Center for Atmospheric Research (NSF NCAR) Boulder, CO
Software Engineer IV (2025–), **III** (2022–2025), **II** (2017–2022) May 2017–Present

- Led development of the ocean component of CESM, a world-leading climate simulation system (>2M LOC, >10k cores) used globally for research and operational prediction.
- Owned software architecture and technical baselines across C++, Python, and Fortran, ensuring correctness, scalability, interoperability, and long-term maintainability of performance-critical simulation software.
- Undertook modernization of legacy Fortran codebases toward modern C++ (C++20) and AMReX, enabling GPU acceleration and performance portability across CPU and GPU platforms.
- Developed an LLVM/Flang-based structural analysis and verification framework that models large Fortran codebases and machine-checks (Lean 4) the equivalence of modernized C++ kernels to legacy Fortran.
- Improved performance and scalability of HPC simulations via profiling (VTune, Nsight) and optimizations: parallel I/O (+15%), land-block elimination (+25%), precision tuning (+50%), and GPU offloading [7].
- Built production Python libraries, APIs, and pipelines for simulation configuration, orchestration, and analysis, including an SMT-based (Z3) configurator that reduced end-to-end setup time from weeks to hours [1].
- Designed and implemented unit, integration, and property-based tests; established automated CI/CD pipelines supporting system-scale validation campaigns on cloud and on-premises HPC platforms.
- Applied formal verification techniques (SMT solvers, theorem provers, model checking) to distributed, physics-based simulation software and numerical ODE/PDE solvers [6], [10], [3], [11].

North Carolina State University (NCSU) Raleigh, NC
Research Assistant May 2011–Dec. 2016

- Designed and implemented an object-oriented finite element hydrodynamics framework in modern C++, supporting adaptive mesh capabilities and distributed, multi-instance simulation workflows [4].
- Developed a reanalysis technique for ADCIRC, a finite-element hurricane storm surge simulation software used by NOAA, USACE, FEMA, and others, improving sensitivity analysis efficiency by ~10x [5].

Education

North Carolina State University Raleigh, NC
Ph.D. in Civil Engineering / Computing & Systems Dec. 2016
M.S. in Civil Engineering / Computing & Systems Dec. 2012
Istanbul Technical University Istanbul, Turkey
B.S. in Civil Engineering June 2010

Skills

Programming:	C++, Python, Fortran, Bash
HPC & Parallelism:	MPI, OpenMP (threading & GPU offloading), AMReX, Dask, Linux, Slurm, PBS
Formal Methods:	Lean 4, Z3, KeYmaera X, Alloy, SPIN, CIVL
Tooling & DevOps:	Git/GitHub, CI/CD, CMake, Docker, AWS, Valgrind, VTune, Nsight
Python Ecosystem:	NumPy, SciPy, pandas, Xarray, JAX, Matplotlib, pytest, hypothesis, Jupyter

Professional Service & Leadership

Organizer.....

- 2025 Tutorial: Rigor and Reasoning in Research Software (R3Sw). *Organized and taught the R3Sw tutorial, together with invited guest lecturers, providing step-by-step training in abstraction, design integrity, testing, formal verification, and explainable AI to over 100 participants. NCAR, Boulder, CO.*
- 2023, 2025 Workshop on Correctness and Reproducibility for Earth System Software. NCAR, Boulder, CO.

Reviewer / Panelist.....

- 2019-Present Program Committee Member: International Workshop on Software Correctness for HPC Applications (Correctness), *held annually at SC.*
- 2024, 2026 Review Panelist: National Science Foundation, Directorate for Computer and Information Science and Engineering (CISE). *Reviewed proposals, served as scribe, and contributed to award recommendations.*
- 2017-2024 Reviewer: Future Generation Computer Systems (FGCS), The Journal of Open Source Software (JOSS), Journal of Advances in Modeling Earth Systems (JAMES)
- 2018 Panelist: “Facilitating the Adoption of Correctness Tools in HPC Applications”. *2nd International Workshop on Software Correctness for HPC Applications. Dallas, TX. November 2018.*

Representation.....

- 2017-Present Software Engineering Liaison: CESM Ocean Model Working Group (OMWG). *Lead software engineering for the ocean component of CESM (MOM6), coordinating development across NSF NCAR and the broader community.*
- 2017-Present NSF NCAR Representative: MOM6 and WAVEWATCH III (WW3, 2022–) development consortia.

Mentorship & Teaching.....

- 2024-Present Supervised and mentored junior software engineers developing scientific modeling tools at NCAR.
- 2024-2025 Mentored NCAR Summer Interns in Parallel Computational Science (SIParCS).
- 2020-2024 Mentored graduate students from UC Davis as part of a collaborative project [7].
- 2025, 2026 Lectured on MOM6 and CESM, and on wave modeling with WW3, at the CROCODILE Workshop on Regional Ocean Modeling with MOM6 in CESM. *NSF NCAR, Boulder, CO.*
- 2022-Present Taught ocean modeling practical sessions at CESM Summer Tutorials.
- 2020 Led a tutorial on using MOM6 within CESM. *MOM6 Webinar Series.*

Awards

- 2025 Better Scientific Software (BSSw) Fellowship. *For leadership in scientific software. Supported by DOE and NSF.*
- 2023 President’s Strategic Initiative Fund Award. *University Corporation for Atmospheric Research.*
- 2019 Special Recognition Award. *NCAR Climate and Global Dynamics Laboratory (CGD).*

Publications

Journal Articles

- [1] A. Altuntas, I. R. Simpson, S. D. Bachman, M. Venumuddula, S. Levis, B. Dobbins, W. J. Sacks, and G. Danabasoglu, “visualCaseGen: An SMT-based Experiment Configurator for Community Earth System Model,” *Journal of Open Source Software*, vol. 11, no. 119, p. 9130, 2026. DOI: 10.21105/joss.09130.
- [2] R. Small, J. Kurian, P. Chang, G. Xu, H. Tsujino, S. Yeager, G. Danabasoglu, W. Kim, A. Altuntas, and F. Castruccio, “Eastern Boundary Upwelling Systems in Ocean–Sea Ice Simulations Forced by CORE and JRA55-do: Mean State and Variability at the Surface,” *Journal of Climate*, vol. 37, no. 9, 2024. DOI: 10.1175/JCLI-D-23-0511.1.
- [3] J. Baugh and A. Altuntas, “Formal methods and finite element analysis of hurricane storm surge: A case study in software verification,” *Science of Computer Programming*, vol. 158, pp. 100–121, 2018. DOI: 10.1016/j.scico.2017.08.012.

- [4] **A. Altuntas** and J. Baugh, “Adaptive subdomain modeling: A multi-analysis technique for ocean circulation models,” *Ocean Modelling*, vol. 115, pp. 86–104, 2017. DOI: 10.1016/j.ocemod.2017.05.009.
- [5] J. Baugh, **A. Altuntas**, T. Dyer, and J. Simon, “An exact reanalysis technique for storm surge and tides in a geographic region of interest,” *Coastal Engineering*, vol. 97, pp. 60–77, 2015. DOI: 10.1016/j.coastaleng.2014.12.003.

Conference Proceedings

- [6] **A. Altuntas**, A. H. Baker, J. Baugh, G. Gopalakrishnan, and S. Siegel, “Specification and Verification for Climate Modeling: Formalization Leading to Impactful Tooling,” in *VSS 2025: International Workshop on Verification of Scientific Software*, 2025. DOI: 10.4204/EPTCS.432.8.
- [7] J. Vanover, **A. Altuntas**, and C. Rubio-González, “Toward Automated Precision Tuning of Weather and Climate Models: A Case Study,” in *SC24-W: Workshops of the International Conference for High Performance Computing, Networking, Storage and Analysis*, IEEE, 2024, pp. 148–159. DOI: 10.1109/SCW63240.2024.00026.
- [8] **A. Altuntas**, J. Baugh, and J. Nusbaumer, “Verifying ParamGen: A Case Study in Scientific Software Abstraction and Modeling,” in *2023 Improving Scientific Software Conference, Boulder, CO, 2023*, 1–9. NCAR/TN-576+PROC. DOI: 10.5065/j0e4-ss70.
- [9] T. Dyer, **A. Altuntas**, and J. Baugh, “Bounded verification of sparse matrix computations,” in *2019 IEEE/ACM 3rd International Workshop on Software Correctness for HPC Applications (Correctness)*, IEEE, 2019, pp. 36–43. DOI: 10.1109/Correctness49594.2019.00010.
- [10] **A. Altuntas** and J. Baugh, “Hybrid theorem proving as a lightweight method for verifying numerical software,” in *2018 IEEE/ACM 2nd International Workshop on Software Correctness for HPC Applications*, IEEE, 2018, pp. 1–8. DOI: 10.1109/Correctness.2018.00005.
- [11] **A. Altuntas** and J. Baugh, “Verifying concurrency in an adaptive ocean circulation model,” in *Proceedings of the First International Workshop on Software Correctness for HPC Applications*, 2017, pp. 1–7. DOI: 10.1145/3145344.3145346.
- [12] J. Baugh and **A. Altuntas**, “Modeling a discrete wet-dry algorithm for hurricane storm surge in Alloy,” in *Abstract State Machines, Alloy, B, TLA, VDM, and Z: 5th International Conference, ABZ 2016, Linz, Austria, May 23-27, 2016, Proceedings 5*, Springer, 2016, pp. 256–261. DOI: 10.1007/978-3-319-33600-8_18.

Tutorial / Workshop

- [13] **A. Altuntas**. “Tutorial: Rigor and reasoning in research software (R3Sw).” In collaboration with invited guest lecturers. (2025), URL: <https://www.alperaltuntas.com/R3Sw/welcome.html>.
- [14] **A. Altuntas** and A. Baker. “2nd workshop on correctness and reproducibility for earth system software.” (2025), URL: <https://ncar.github.io/correctness-workshop/>.

Technical Report

- [15] **A. Altuntas**, A. Baker, I. Carpenter, B. Dobbins, M. Duda, D. Hammerling, T. Hauser, and K. Peters-von Gehlen, “Report on the 2023 Workshop on Correctness and Reproducibility for Climate and Weather Software,” NCAR/TN-582+PROC, 2024. DOI: 10.5065/0534-mc88.