

Andreas Müller

Curriculum Vitae

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Current position

August 2012 – present **Department for Applied Mathematics, Naval Postgraduate School, Monterey, CA, USA, NRC Associate.**

Project Title: Optimizing adaptive mesh refinement in a DG atmospheric model. Supervised by Prof. Dr. Francis X. Giraldo

Education

July 2012 **PhD, Natural Sciences**, University of Mainz, Germany.

Accuracy of adaptive DG simulations of idealized 2D bubble test cases. Advisor: Prof. Dr. Volkmar Wirth

July 2008 **MSc, Physics**, University of Mainz, Germany.

Thesis: Resolution dependence of the tropopause inversion layer in an idealized model for upper tropospheric anticyclones. Advisor: Prof. Dr. Volkmar Wirth

April 2005 **BSc, Physics**, University of Mainz, Germany.

Research Experience

2012–Present **Postdoctoral Research**, *Department for Applied Mathematics, Naval Postgraduate School, Monterey, CA.*

Project title: *Optimizing adaptive mesh refinement in a DG atmospheric model.*

- Analyzed the cache efficiency of the atmospheric model NUMA (Non-hydrostatic Unified Model of the Atmosphere) which is used by the Naval Research Lab, Monterey, as the dynamical core for the next generation weather prediction system NEPTUNE
- Ported NUMA to the Blue Gene and made scalability studies up to the entire 3.14 million hardware threads of Mira.
- Optimized main kernel of NUMA for SIMD vectorization by the compiler
- Optimized main kernel of NUMA by using BG/Q vector intrinsics
- Added hybrid MPI-OpenMP parallelization to NUMA
- Visualized scientific results of clouds simulations with Autodesk Maya
- Studied different measures for the efficiency of a numerical code
- Performed a study of the efficiency of adaptive and uniform simulations with spectral element and discontinuous Galerkin methods for spatial discretization order ranging from 3 to 11 for a dry and a moist test case using Kessler physics.

2008–2012 **Doctoral Research**, *Institute for Atmospheric Physics, University of Mainz, Germany.*

Project title: *Adaptive numerical modelling of atmospheric moist convection.*

- Developed the adaptive numerical model CloudFlash for the compressible Euler equations using discontinuous Galerkin method on a triangular mesh using space filling curves via the function library AMATOS
- Added shared-memory OpenMP parallelization to CloudFlash
- Developed a physical error indicator
- Compared the efficiency between adaptive and uniform simulations of a rising thermal bubble test case

- 2006–2008 **Research Assistant**, *Institute for Atmospheric Physics, University of Mainz, Germany.*
Project title: *The tropopause inversion layer in a high resolution balanced model.*
- Developed a finite difference model for the tropopause inversion layer
 - Performed a convergence study

Research Interests

High performance computing, performance analysis and performance optimization
Application of adaptive mesh refinement to atmospheric problems
High-order spectral element and discontinuous Galerkin methods
Efficiency comparison between different numerical methods
Numerical simulation of atmospheric convection
Parameterizations for describing unresolved physical processes
Scientific visualization with computer graphics software (e.g. Blender, Autodesk Maya)

Awards

- 2012 National Research Council Postdoctoral Fellow, 4 year grant, USA
2012 Newton Institute for Mathematical Sciences – Cambridge University. Fellowship: Program on Multiscale Numerics for the Atmosphere and Ocean. Aug – Dec 2012
2010 Junior member of the Gutenberg Academy. 2010 – 2012. Mainz, Germany.

Additional Training

- Aug 2014 Argonne Training Program on Extreme Scale Computing (2 weeks)
Feb 2010 Winter school (2 weeks): Advanced Numerical Methods for Hyperbolic Equations and Applications, Trento, Italy
Nov 2009 Oberwolfach Seminar (1 week): Computational Fluid Dynamics, Mathematisches Forschungsinstitut Oberwolfach, Germany
Aug 2008 MetStröm summer school (4 weeks): Multiscale Problems in Fluid Dynamics and Meteorology, Berlin, Germany

Professional Service

Reviewer for: Monthly Weather Review
Quarterly Journal of the Royal Meteorological Society
Computer Physics Communications

Teaching Experience

- Research **University of Mainz**, Institute for Atmospheric Physics.
Supervisor I have directed the work of a research assistant and the work for his Diplom thesis.
Naval Postgraduate School, Department for Applied Mathematics.
I have supervised the work of a summer intern.
- Lecturer **Meteorological Programming and Numerics 2011**, *April – July 2011*,
Compulsory lecture for undergraduate students in meteorology in their second year.
Introduction into numerical methods and programming with Fortran.

Meteorological Programming and Numerics 2010, April – July 2010,
Compulsory lecture for undergraduate students in meteorology in their second year.
Introduction into numerical methods and programming with Fortran.

Teaching **Atmospheric Dynamics Part I and II**, October 2008 – July 2009.

Assistant Introduction into hydrodynamics for meteorology students.

Most Relevant Publications

Peer-reviewed

- 2015 Marras, S., J.F. Kelly, M. Moragues, **A. Müller**, M.A. Kopera, M. Vázquez, F.X. Giraldo, G. Houseaux, and O. Jorba, *A review of element-based Galerkin methods for numerical weather prediction. Finite elements, spectral elements, and discontinuous Galerkin*, Archives of Computational Methods in Engineering 04/2015. DOI:10.1007/s11831-015-9152-1.
- 2014 Yelash, L., **A. Müller**, M. Lukacova-Medvidova, F.X. Giraldo, and V. Wirth, *Adaptive discontinuous evolution Galerkin method for dry atmospheric flow*, Journal of Computational Physics. 268C (2014) 106 - 133.
- 2013 **Müller, A.**, J. Behrens, F. X. Giraldo, and V. Wirth, *Comparison between adaptive and uniform discontinuous Galerkin simulations in dry 2D bubble experiments*, Journal of Computational Physics. 235 (2013) 371 - 393.
- 2009 **Müller, A.**, and V. Wirth, *Resolution dependence of the tropopause inversion layer in an idealized model for upper tropospheric anticyclones*, Journal of the Atmospheric Sciences, Vol. 66, No. 11, pp. 3491–3497

In Preparation for Peer-Review

- 2015 **Müller, A.**, M.A. Kopera, S. Marras, L.C. Wilcox, T. Isaac, and F.X. Giraldo, *Strong scaling for numerical weather prediction at petascale with the atmospheric model NUMA*, submitted to 30th IEEE International Parallel & Distributed Processing Symposium 2016. <http://arxiv.org/abs/1511.01561>
- **Müller, A.**, and F.X. Giraldo, *Towards numerical weather prediction at exascale with the dynamical core NUMA*
 - **Müller, A.**, M.A. Kopera, and F.X. Giraldo, *How much efficiency is gained by using AMR and high order DG for the 2D warm air bubble test case?*

Conference Proceedings

- 2014 Marras, S., **A. Müller**, F. X. Giraldo, *Physics-based stabilization of spectral elements for the 3D Euler equations of moist atmospheric convection*, Proceedings of ICOSAHOM 2014, Salt Lake City, UT, USA
- 2010 **Müller, A.**, J. Behrens, F.X. Giraldo, and V. Wirth, *An adaptive discontinuous Galerkin model for modeling cumulus clouds*, Proceedings of the V European Conference on Computational Fluid Dynamics ECCOMAS CFD 2010, ISBN: 978-989-96778-1-4

Thesis

- 2012 **Müller, A.**, *Accuracy of adaptive DG simulations of idealized 2D bubble test cases*, PhD thesis, <http://ubm.opus.hbz-nrw.de/volltexte/2012/3168/>
- 2008 **Müller, A.**, *Die Tropopauseninversionsschicht in einem hochaufgelösten balancierten Modell*, Diplom thesis.

Most Relevant Presentations

Invited Talks

- 2015 **Müller, A.**, M. Kopera, S. Marras, and F. X. Giraldo, *Parallel performance of the atmospheric model NUMA using element-based Galerkin methods*, Institute for Numerical Simulation, University of Bonn, Germany.
- 2014 **Müller, A.**, M. Kopera, S. Marras, D. S. Abdi, and F. X. Giraldo, *Efficiency of high-order continuous and discontinuous Galerkin methods*, German Weather Service DWD, Offenbach, Germany.
- **Müller, A.**, *Challenges and Opportunities of upcoming Supercomputers for NWP*, Institute for Atmospheric Physics, University of Mainz, Germany.
- 2013 **Müller, A.**, *Computational and numerical challenges in weather prediction*, INVASIC seminar, Munich, Germany.
- 2012 **Müller, A.**, *Testing refinement criteria in adaptive discontinuous Galerkin simulations of dry atmospheric convection*, Seminar Scientific Computing , Hamburg, Germany.
- 2010 **Müller, A.**, *Adaptive discontinuous Galerkin methods - An introduction with application to cloud modeling*, Theorie-Seminar Frankfurt, Germany.

Conference Presentations

- 2015 **Müller, A.**, D. S. Abdi, M. Kopera, L. Wilcox, and F. X. Giraldo, *Towards operational weather prediction at 3.0km global resolution with the dynamical core NUMA*, Workshop on the Solution of Partial Differential Equations on the Sphere, KIAPS, Seoul, South Korea
- **Müller, A.**, M. Kopera, and F.X. Giraldo, *Strong scaling on more than 700,000 cores with the atmospheric model NUMA*, Workshop Galerkin methods with applications in weather and climate forecasting, ICMS, Edinburgh, Scotland
- 2014 **Müller, A.**, M. Kopera, S. Marras and F.X. Giraldo, *Does high order and dynamic adaptive mesh refinement improve the efficiency of atmospheric simulations?*, Coupling physics and dynamics workshop, CICESE, Ensenada, Mexico
- **Müller, A.**, M. Kopera, S. Marras and F.X. Giraldo, *Do high order and dynamic adaptive mesh refinement improve the efficiency of atmospheric simulations?*, World Weather Open Science Conference, Montreal, Canada
 - **Müller, A.**, M. Kopera, S. Marras and F.X. Giraldo, *Comparison of adaptive and uniform 2D Galerkin simulations*, Workshop on the Solution of Partial Differential Equations on the Sphere, NCAR, Boulder, USA
- 2013 **Müller, A.**, M. Kopera, and F.X. Giraldo, *Comparison of adaptive and uniform DG simulations*, SIAM Geoscience Meeting, Padova, Italy
- 2012 **Müller, A.**, J. Behrens, F. X. Giraldo and V. Wirth, *Accuracy of adaptive discontinuous Galerkin methods*, Workshop on the Solution of Partial Differential Equations on the Sphere, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK
- **Müller, A.**, *Are adaptive simulations more accurate than uniform simulations?*, Workshop Adaptive Multiscale Methods for the Atmosphere and Ocean, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK
- 2011 **Müller, A.**, J. Behrens, F. X. Giraldo and V. Wirth, *An adaptive discontinuous Galerkin model for the 2D, compressible Navier-Stokes equations*, SIAM Conference on Mathematical & Computational Issues in the Geosciences, Long Beach, USA

- **Müller, A.**, J. Behrens, F. X. Giraldo, O. Kunst, V. Wirth and G. Wolf, *An adaptive discontinuous Galerkin method for modelling moist convective updrafts*, International MetStröm Conference, Berlin, Germany
- 2010 **Müller, A.**, J. Behrens, F. X. Giraldo and V. Wirth, *An adaptive discontinuous Galerkin for the 2D, compressible Navier-Stokes equations*, Workshop on the Solution of Partial Differential Equations on the Sphere, Potsdam, Germany
- **Müller, A.**, J. Behrens, F. X. Giraldo and V. Wirth, *An adaptive discontinuous Galerkin for modeling cumulus clouds*, Mathematical Theory and Modelling in Atmosphere-Ocean-Science, MFO Oberwolfach, Germany
 - **Müller, A.**, J. Behrens, F. X. Giraldo and V. Wirth, *An adaptive discontinuous Galerkin for modeling cumulus clouds*, V European Conference on Computational Fluid Dynamics ECCOMAS CFD, Lisbon, Portugal
- 2009 **Müller, A.**, *Application of discontinuous Galerkin methods to adaptive modeling of atmospheric dry convection*, Hirschegg-Workshop, Austria
- **Müller, A.**, J. Behrens and V. Wirth, *Adaptive numerical modeling of atmospheric moist convection*, Workshop Multi-scale Modelling of the Atmosphere and Ocean, Reading, UK, poster
- 2007 **Müller, A.** and V. Wirth, *Die Tropopauseninversionsschicht in einem hochaufgelösten balancierten Modell*, DACH 2007, Hamburg, Germany