Aaron Ridley

Curriculum Vitae

May 14, 2021

Education

- B.S. in Physics, 1992, Eastern Michigan University
- M.S. in Atmospheric and Space Sciences, 1995, University of Michigan
- Ph.D. in Atmospheric and Space Sciences, 1997, University of Michigan
  - Thesis title: Ionospheric Convection
  - Thesis advisors: C. Robert Clauer and Gang Lu

Professional History

- Professor, University of Michigan, 2013-
- Associate Professor, University of Michigan, 2006-2013
- Associate Research Professor, University of Michigan, 2005-2009
- Associate Research Scientist, University of Michigan, 2003-2005
- Assistant Research Scientist, University of Michigan, 2000-2003
- Research Scientist, Southwest Research Institute, San Antonio, Texas, 1997-1999
- Research Assistant, High Altitude Observatory, NCAR, Boulder, CO, 1996-1997

Honors and Awards

- 2018 - UM's College of Engineering Ted Kennedy Family Faculty Team Excellence Award (Center for Space Environment Modeling)
- 2017 - Mission of the Year at Small Satellite Conference for CYGNSS
- 2016 - UM's College of Engineering Ted Kennedy Family Faculty Team Excellence Award (CYGNSS satellite mission team)
- 2012 - University of Michigan's College of Engineering Monroe-Brown Foundation Education Excellence Award
- 2004 - University of Michigan's College of Engineering Outstanding Research Scientist Award
- 1996 - National Center for Atmospheric Research High Altitude Observatory's Newkirk Fellowship

Teaching History

New courses introduced at U of M:

- **ENGR 100 – Rocket Science:** I took the Rocket Science class that was created for general science students (as described below), and moved it to the College of Engineering in Fall of 2021, making it into a project-based class. In this class, we discuss the basic physics of rockets and orbits, have weekly labs, and then complete a project. The labs are focused around using computers to solve problems, work up from creating simple integration examples to launching a ballistic rocket and simulating its completely flight. The students then launch model rockets and compare their flight results to their numerical prediction. The most popular project in this class is attempting to design a mission to deflect a society-destroying asteroid that will encounter Earth in seven years. The students go through a number of deflection strategies, and then design a mission that will balance the amount of time for designing and building the system and having enough time to divert the asteroid.

- **ENGR 100 - Electronics for Atmospheric and Space Measurements:** In this class, first offered in Winter 2017, students learn how to use a systems approach to build a sensor board using a micro-controller to take both in situ and remotely sensed observations of a high-altitude environment. The topics include: Sampling the sensors and storing the data on-board; designing and building simple circuits for these types of applications; writing programs for controlling the sensors and data on the micro-controller as well as plotting the stored data on a computer; testing the system that they build for robustness; deploying their system in different places; learning and applying flight procedures and best practices for high-altitude balloon flights; and processing and interpreting the sensor measurements post-launch. The payloads that are built and tested are deployed on a high-altitude balloon launch, in which the payloads are carried to about 100,000 ft. altitude, and the students analyze the data that they collect from the balloon launch. In 2019, we tried to have some gamification component to the grading, allowing the students to take more ownership of what they wanted to get from the class. We are continuing this aspect in 2020.
- **SPACE 310 - Satellite Mission Design:** This class is aimed at teaching the fundamentals of designing a satellite mission, and was taught through the use of projects and examples. A number of different example satellite missions were explored, ranging from low Earth orbit to interplanetary, and from single satellite missions to constellation missions. A list of topics that were discussed include: (1) different subsystems on satellites; (2) formulating instrument requirements and how to flow those requirements down to different subsystems and the mission; (3) power, mass, data, and financial budgets; (4) contingency and margin; (5) calculating solar power and battery depth of discharge; (6) thermal considerations; (7) orbits and launch vehicles; and (8) attitude determination and control systems. This was an introductory class, and so was open to all student levels. Students design a large-scale mission in the last month of the class. Examples include: a Titan (moon of Saturn) submarine, a Mars orbiter for finding surface water, and an Earth observing mission for tracking changes in ice and snow.
- **AOSS 477 - Modeling the Space Environment:** This course is focused on teaching students to use models of the near-Earth space environment. For each model, the students have to devise a sensitivity test, in which they varied different input parameters to determine how the model reacted. They then have to compare the model results to data for some real event. Each model in the sequence is progressively more difficult to use, until the final model, which the students is to prepare a much longer write-up. This class teaches senior-level and graduate-level students about space-based models, how to write a scientific paper, and how to plan and implement experiments.
- **SPACE 101 - Rocket Science:** This class teaches some basics about rocket science - how rockets work, who created the first rockets, which countries did what in the space race, where satellites orbit, how to get to the moon and Mars and other places and other interesting things about NASA, the USSR, space, airplanes, energy, motors, lightsabers, teleportation, etc. A list of specific topics covered includes: history of rocket science (pre WWII, WWII, The Space Race, the decline); some basic physics (Newton, forces, thrust, etc.); engines of all sorts (cars, electric, generators, etc.); rocket engines (solids, liquids, hybrids, nuclear, etc.); Orbits (Kepler, low, Geo, transfers, interplanetary, interstellar); satellite missions (Voyager, Galileo, Messenger, the Space Shuttle, etc.); the space environment (the sun and heliosphere, radiation belts, aurora, etc.); and politics of space. I also ran a one credit hour class for a few semesters in which we went over the mathematics of rocket science in much more detail (titled the Mathematics of Rocket Science).

- **AOSS 605 - NanoSat Design:** Student teams take initial designs of small satellite systems and refine them significantly. Each team is assigned a subsystem to refine, with collections of teams working on an entire satellite. Subsystems include power, communication, attitude determination and control, thermal, central processing, data storage, structure, and payload interface. After initial selection of components, flow down of requirements, interfaces and interference on other subsystems are investigated. Documentation of each of these is stressed. The class is discussion oriented with some lectures on requirements for subsystems, documentation and designs, with weekly progress updates and monthly reports. The end result of the class is a more-complete description of each satellite system with full documentation.

Courses taught at U of M (See Table Below)

Course	Course title	Teaching Role	Term
ENG 100	Rocket Science	Instructor	Fall 2022
ENG 100 SPACE 584 ENG 100	Electronics for Atmospheric and Space Measurements Space Instrumentation Rocket Science	Instructor Instructor Instructor	Winter 2022 Winter 2022 Fall 2021
ENG 100 SPACE 584 SPACE 310	Electronics for Atmospheric and Space Measurements Space Instrumentation Satellite Mission Design	Instructor Instructor Instructor	Winter 2020 Winter 2020 Fall 2019
ENG 100 SPACE 310 ENG 430	Electronics for Atmospheric and Space Measurements Satellite Mission Design Honors Seminar - III	Instructor Instructor Instructor	Winter 2019 Fall 2018 Fall 2018
ENG 100 ENG 430	Electronics for Atmospheric and Space Measurements Honors Seminar - III	Instructor Instructor	Winter 2018 Winter 2018
SPACE 405 ENG 490	Satellite Mission Design Special Topics in Engineering (Honors Seminar - III)	Instructor Instructor	Fall 2017 Fall 2017
ENG 100 ENG 490	Electronics for Atmospheric and Space Measurements Special Topics in Engineering (Honors Seminar - III)	Instructor Instructor	Winter 2017 Winter 2017
SPACE 405 ENG 290	Satellite Mission Design Special Topics in Engineering (Honors Seminar - I)	Instructor Instructor	Fall 2016 Fall 2016
ENG 101 ENG 290	Introduction to Computer Programming Special Topics in Engineering (Honors Seminar - I)	Instructor Instructor	Winter 2016 Winter 2016
AOSS 101 AOSS 205 ENG 290	Rocket Science Rocket Science Math Special Topics in Engineering (Honors Seminar - I)	Instructor Instructor Instructor	Fall 2015 Fall 2015 Fall 2015
ENG 101 ENG 290 AOSS 590	Introduction to Computer Programming Special Topics in Engineering (Honors Seminar - I) Space Systems Projects	Instructor Instructor Instructor	Winter 2015 Winter 2015 Winter 2015
AOSS 101 AOSS 205	Rocket Science Rocket Science Math	Instructor Instructor	Fall 2014 Fall 2014
AOSS 495 AOSS 605 AOSS 584	Upper Atmosphere and Ionosphere NanoSat Design Space Instrumentation	Instructor Instructor Co-Instructor	Winter 2014 Winter 2014 Winter 2014
AOSS 584 AOSS 477	Space Instrumentation Modeling the Space Environment	Instructor Co-Instructor	Winter 2013 Winter 2013
AOSS 605 AOSS 101	NanoSat Design Rocket Science	Instructor Instructor	Fall 2012 Fall 2012
AOSS 605 AOSS 495	NanoSat Implementation Upper Atmosphere and Ionosphere	Instructor Instructor	Winter 2012 Winter 2012
AOSS 605 AOSS 101	NanoSat Design Rocket Science	Instructor Instructor	Fall 2011 Fall 2011
AOSS 584	Space Instrumentation	Instructor	Winter 2011
AOSS 101	Rocket Science	Instructor	Fall 2010
AOSS 584	Space Instrumentation	Instructor	Winter 2010
AOSS 101	Rocket Science	Instructor	Fall 2009
AOSS 101	Rocket Science	Instructor	Winter 2009
AOSS 101	Rocket Science	Instructor	Fall 2008
AOSS 584 AOSS 499	Space Instrumentation Modeling the Space Environment	Instructor Co-Instructor	Winter 2008 Winter 2008
AOSS 102	Extreme Weather	Instructor	Fall 2007
AOSS 462 AOSS 584	Instrumentation for Atmospheric and Space Sciences Space Instrumentation	Instructor Instructor	Winter 2007 Winter 2007
AOSS 595	Magnetospheres	Instructor	Fall 2006
AOSS 462	Instrumentation for Atmospheric and Space Sciences	Instructor	Winter 2006

AOSS 584	Space Instrumentation	Co-Instructor	Winter 2005

Ph.D. Committees chaired/co-chaired

1. Brandon Ponder, fourth year Ph.D.
2. Daniel Brandt, August 2021, Chair (Current Position: Michigan Tech. Research Center).
3. Garima Malhotra, April 2021, Chair (Current Position: NOAA/SWPC in Boulder, CO).
4. Nicholas Perlongo, April 2017, "Hemispheric Asymmetries of Magnetosphere-Ionosphere-Thermosphere Dynamics", Chair. (Current Position: Lockheed Martin in Washington DC)
5. Charles Bussy-Virat, January 2017, "Satellite Collision Avoidance", Chair. (Current Position: Post Doc, University of Michigan)
6. Jie Zhu, December 2015, "The Effect of Energy Input on the Earth's Upper Atmosphere". Chair. (Current Position: Microsoft, Seattle, WA)
7. Alexey Morovoz, Apr. 2013, "Data Assimilation and Driver Estimation for Space Weather Models using Ensemble Filters". Committee Member.
8. Anthony D'Amato, Feb. 2012, "Adaptive Input Reconstruction with Application to Model Refinement, State Estimation, and Adaptive Control". Committee Member. (Current position with Ford in Dearborn, MI)
9. Yiqun Yu, 2010, "On the regulation of the geospace system by solar-wind/IMF discontinuity and ionospheric outflow". Chair. (Current position: Assistant Professor, Beihang University, Beijing, China)
10. Raluca Ilie, 2010, "Exploring storm time ring current formation and response on the energy input". Committee Member. (Current position: Assistant Professor, University of Illinois)
11. David Pawlowski, 2009, "On the response of the upper atmosphere to solar flares". Chair. (Current position: Assistant Professor, Eastern Michigan University)
12. Daniel Welling, 2008, "Exploring source of magnetospheric plasma using the validated SWMF". Co-Chair. (Current position: Assistant Research Scientist, University of Michigan)
13. Jason Gilbert, 2008, "Advanced instrumentation and flux mapping techniques for the study of the space environment". Committee Member. (Current position: Assistant Research Scientist, University of Michigan)
14. Anna DeJong, 2008. "Studies of magnetospheric convection: Balanced and unbalanced". Co-Chair. (Current position: Assistant Professor, Christopher Newport University)
15. Jared Bell, 2008. "The dynamics in the upper atmospheres of Mars and Titan". Committee Member. (Current position: Research Scientist, National Institute of Aerospace)
16. Insung Kim, 2008. "Reduced-Complexity Algorithms for Data Assimilation of Large-Scale Systems". Co-Chair. (Current Position KARI in South Korea)
17. Jaganath Chandrasekar, 2007. "Reduced-complexity algorithms for data assimilation of large-scale systems". Co-Chair. (Current position with TRW in Livonia, MI)
18. Harish Palanthandalam-Madapusi, 2007. "Nonlinear system identification with applications to space weather". Co-Chair. (Current position IIT Gandhinagar in India)
19. Xia Cai, 2007. "Investigation of global periodic sawtooth oscillations observed in energetic particle flux at geosynchronous orbit". Committee Member. (Current position: Research Scientist, Virginia Tech).
20. Yue Deng, 2006. "Examining the high latitude thermosphere and ionosphere using a global model". Chair. (Current position: Associate Professor, University of Texas, Arlington).
21. Jichun Zhang, 2006. "Understanding storm-time ring current sources: Data analysis and global modeling". Committee Member. (Current position: Research Scientist, University of New Hampshire)
22. Joseph Baker, 2001. "Winter auroral morphology and substorm electrodynamics". Committee Member. (Current position: Professor, Virginia Tech)

Undergraduate major projects directed

- Faculty advisor for the Student Space Systems Fabrication Laboratory (S3FL), a student group with approximately 100 students working on various space-related hardware projects, 2017-.
- Faculty advisor to the M-BARC project which was directed at launching two CubeSats for the UM Bicentennial, about 50 students, 2016-2018.
- Lead a team of students and engineers in building two CubeSats for the European-led QB50 mission, about 20 students, 2013-2016.
- Revised the Engineering 101 (Introduction to Computer Programming) course 2014-2015.
- Faculty advisor for the University of Michigan's Solar Car team during the 2013 World Solar Championship.
- ME450 project on designing a reaction wheel for attitude control of a satellite (2014).
- CubeSat investigating Atmospheric Density Response to Extreme driving (CADRE), about 75 students, 2011-2015.
- Faculty advisor for the MBuRST high-altitude ballooning student group, part of S3FL. MBuRST typically has 8-15 student involved each year (2008-). Faculty advisor for the CanSat student competition group, part of S3FL. CanSat typically has 10-15 freshmen and sophomore students involved each year (2016-2019). Faculty advisor for the Robotic Exploration of Space Team (REST), which is part of S3FL and participates in NASA mining competitions (2017-).

Outreach directly related to teaching

- High School Robotics, Home School Central, 2012-2013.
- High School Physics Laboratory, Home School Central, 2011-2012.

Service History

Major committee assignments in the Department, College, and/or University

- Associate Chair of Education, Department of Climate and Space Science and Engineering (CLaSP, 2018-)
- Chair of Faculty Hiring Committee (CLaSP, 2021-2022)
- College of Engineering Community of Practice Committee for Engineering 100 (2020)
- College of Engineering Math Curriculum Review Committee (2018-2019)
- CLaSP Curriculum Committee (2014-)
- CLaSP Strategic Planning Committee (2016- 2017)
- CLaSP Awards Committee (2004-2005, 2015-2016)
- Depart. of Atmospheric, Oceanic and Space Sciences (AOSS) Development Committee (2012)
- AOSS Department Review Committee (2012)
- AOSS Qualification Exam Co-Chair (2012- 2013)
- AOSS Executive Committee (2002-2004, 2011-2013)
- AOSS Nominations Committee (2012)
- College of Engineering Commission on Undergraduate Engineering Education (2008-2009)
- Organization of student labs for AOSS (2007-2008)
- Assisted in the creation of a College of Engineering Multidisciplinary Design Minor (2007)
- College of Engineering Research Strategy Committee (2007)
- AOSS Information Technology Committee (2006-2012)
- AOSS Core Curriculum Committee (2006- 2008)
- AOSS Graduate Committee (2004-2005)
- Assisted in the restructuring of the AOSS graduate program (2003)

Administrative duties at U of M

- Faculty Advisor for the College of Engineering Student Space Systems Fab. Lab. (2017-)
- Faculty Advisor for the College of Engineering Honor's Program (2012-2019)
- Provost's Council on Student Honors (2017-2019)
- Faculty Advisor for the UM's Michigan Bicentennial Archive project (2017- 2018)
- Faculty Advisor for the UM's Solar Car Team (World Solar Championship - 2013)
- AOSS Undergraduate Advisor (2006-2013)

Service to government or professional organizations

- Advisory Board for the High Altitude Observatory (2021-)
- Co-Chair of NASA's Geospace Dynamics Constellation Science and Technology Definition Team (2018-2019)
- Committee on Best Practices for a Future Open Code Policy for NASA Space Studies, National Academy of Sciences (2017-2018)
- Assessment of National Science Foundation Geospace Portfolio Review, National Academy of Sciences (2016)
- Committee on Solar and Space Physics, National Academy of Sciences (2012-2016)
- National Science Foundation's Coupled Energetics and Dynamics in Atmospheric Regions (CEDAR) Science Steering Committee (2012-2015)
- Secretary for the American Geophysical Union Space Physics and Aeronomy, Magnetospheric Physics section (2010-2012)
- National Science Foundation Review Board for the High Altitude Observatory (2011)
- Member of the Steering Group for the European CubeSat mission QB50 (2011)
- Working group co-chair for the NCAR Community Climate Model (2008-2010)
- Organization of the ionosphere-thermosphere community to support space-based and ground-based research (2007-2010)
- NOAA Data Archive Access Requirements Working Group (2006-2007)
- NASA Sun Solar System Connections Science Data and Computing Working Group (2003-)
- Geospace Environment Modeling Steering Committee (2002-2006)
- Co-leader of the international organization ICESTAR (2004)
- "Geophysics the Future" Working Group for International Union of Geodesy and Geophysics (2002-2003)
- I have served on many proposal review panels for NASA and NSF, but I have never kept track of when they have occurred.

Contribution to diversity and climate

- As faculty advisor for the College of Engineering (CoE) Honors program, I constantly strove to increase the diversity and inclusiveness of the program. We constantly attempted to explore what we could do as program to increase the diversity of the CoE in a sustainable way.
- I purposefully try to make my classes and research group as inclusive as possible. I feel like this is very hard to quantify, but I strive to make underrepresented people feel as welcome as possible. I have tried to do this through the hiring of a diverse group of people into my research group, such as undergraduates, graduate students, and post docs, and through the hiring of diverse instructional assistants for classes.

Outreach that is not part of research or teaching, or entrepreneurship

- Creation of videos to assist students in learning engineering: Hands On Engineering channel on youtube.com.

- Personal blog, where I talk about what it is like being a professor and other aspects of being a human: aaronridley.wordpress.com.
- Rocket Science blog, where I talk about the physics of rocket science and other physics topics: therocketscienceblog.wordpress.com.
- X and Why Podcast, where my friend and I talk about life as professors and interview different people on being a scientist or an engineer: xandwhy.xyz.

Mentoring activities involving junior faculty or post-doctoral scholars

- Chen Wu (2019-)
- Charles Bussy-Virat (2017-)
- Cai Lie (2016-2017)
- Xianjing Liu (2014-2015)
- Ye Gao (2013-2014)
- Angeline Burrell (2012-2014)
- Erdal Yiğit (2010-2012)
- Hui Wang (2007-2009)

Research

Research programs underway

I have an extremely broad research interest, and have published research studies ranging from launching acoustic waves in the thermosphere to predicting the solar wind velocity five days in advance to determining the most efficient orientation of solar panels on a CubeSat. When I think about research in general, I think about two aspects: the techniques to conduct research, and the subjects that are studied. I consider myself to be an enabler of research through the development of a variety of tools. These tools focus on four areas:

- **Modeling of the near-Earth space environment.** I have worked with and have developed many different models of the upper atmosphere and magnetosphere. Towards the beginning of my career, I worked with the Assimilative Model of Ionospheric Electrodynamics (AMIE), which was developed at the National Center for Atmospheric Research (NCAR). I ended up rewriting the data processing codes and, eventually, the entire code. AMIE used to be used on a case-by-case basis, but I created algorithms to allow it to be run for over 20 years of time. During my post doc, I worked on porting the TIEGCM, another NCAR model, to a Linux environment. After I moved to the University of Michigan, I worked with the BATSRUS MHD model of the magnetosphere, and coupled this to the TIEGCM. I further created an ionospheric electrodynamics model for BATSRUS and created code to allow BATSRUS to be run off of realistic, ever-changing, boundary conditions. The coupling that was done with BATSRUS was part of the Space Weather Modeling Framework (SWMF), which links together a wide variety of models of the geospacer environment. I was one of the original developers of the SWMF, and helped to develop the fundamental architecture of the framework. I also developed a Global Ionosphere Thermosphere Model (GITM), which is significantly more flexible than existing upper atmosphere models (high resolution grid, no hydrostatic assumptions, flexible drivers). This code has been ported over to work on Mars, Titan, and Saturn in addition to Earth, and versions for Jupiter and Venus are being worked on. The majority of the research grants that I currently have are to utilize GITM for studying different aspects of the near-Earth space environment. I have published papers on validating various models and have started to investigate how we can statistically quantify how well models simulate the natural world. Recently, we have developed a model to predict the hourly solar wind velocity for up to five days using probability density functions, allowing the uncertainty in the prediction to be known. We have created an extremely precise satellite orbit propagator that will allow the analysis of collisions using ensembles of satellite characteristics and thermospheric states. This tool can be used for mission planning, event analysis, and collision avoidance maneuver decisions. We have started to use this model to derive the thermospheric density given both precise GPS-based satellite orbits and imprecise daily two-line element from a constellation of satellites. Finally, we are currently working on a new empirical model of the aurora which focuses on capturing the features of the aurora (such as the boundaries and the peak location and flux). Most of my graduate students and Postdoctoral Researchers have used these models to conduct research on the near-Earth space environment.

- **Satellite Missions.** I have been funded to fly four CubeSats: CADRE, Atlantis, Columbia, and DSM-BARC, was the Constellation Scientist on the NASA CYGNSS mission, have led two explorer-class proposals, and was the co-chair of the Geospace Dynamics Constellation (GDC) Science and Technology Definition Team. CADRE, Atlantis and Columbia were designed to measure aspects of the thermosphere and ionosphere and were funded by the National Science Foundation. CADRE was deployed from the International Space Station in May of 2016, while Atlantis and Columbia were part of the QB50 mission and were deployed from the ISS in May of 2017. DSM-BARC was part of the University of Michigan's bicentennial celebration. These CubeSats have all had significant involvement by undergraduate and masters-level students. CYGNSS is an 8-satellite constellation mission to measure the surface winds in hurricanes using reflected GPS signals. I was involved with the CYGNSS proposal development, mission design, planning, and implementation, and helped to determine many of the critical aspects of the mission. I have led a NASA Small Explorer proposal with six small satellites totaling $115,000,000 and a Medium Explorer proposal with four satellites measuring the aurora in both hemispheres for $250,000,000. GDC is the next Heliophysics Living with a Star mission and has an anticipated budget of $500M to $1,000M.
- **Ground-based Wind Measurements.** As part of a collaborative team, I have helped to deploy and operate a network of ground-based Fabry Perot Interferometers. These measure the neutral winds at 250 km altitude during the night. We have deployed one station near Ann Arbor, MI, and have been funded to build two more and deploy these in Finland and Sweden.
- **Data assimilation.** The natural combination of observations and models is data assimilation. I have been working with faculty in the University of Michigan Aerospace Department to develop new algorithms for merging data with models. This has evolved from using classic techniques such as a Kalman Filter to using newly developed techniques based on the latest control theories.

In addition to development of tools for studying the near-Earth space environment, I have actually published a wide variety of articles that focus on many science questions. In general, the themes that I have focused on are:

- **How the thermosphere and ionosphere respond to energy input.** Using GITM, we have explored a wide variety of aspects on how the upper atmosphere responds to different types of energy input, such as the aurora, high-latitude Joule heating, and solar flares. We have explored how the thermosphere can have non-hydrostatic responses to the input, and how the system can respond to the same inputs differently depending on things such as the season and the time of day. We explored hemispheric asymmetries in the system, and how the Earth's magnetic field can control the response.

- **How the auroral precipitation is controlled.** The aurora is a fundamental process that links the magnetosphere and ionosphere, but it is extremely difficult to specify and predict using first principle models of the system, which must be improved if we are to make progress in predict various Space Weather parameters.
- **Understanding the drivers of ionospheric outflow and their magnetospheric consequences.** Mass loading of the magnetosphere has been shown to alter how it responds to energy input from the solar wind using global models, but it has been extremely difficult to determine whether the predictions are accurate. Further, determining when and where outflow occurs has also been quite difficult and is an important area of study if we are to understand the behavior of our near-Earth space environment.
- **How we can use ensemble models to predict Space Weather.** The Heliospheric field tends to use deterministic models of the environment, where a single prediction is made with no specification of the uncertainties of the prediction. Other fields use probabilistic models, where a variety of models are run in order to give an indication of the uncertainty or probability of an event occurring. Transitioning our field towards using probabilistic model prediction is important but hard due to the complexity of the simulations and the lack of understanding of the uncertainties in the model parameters and drivers.

New research directions

There are four areas in which I am pushing my research group:

- **Improving our ability to simulate the upper atmosphere.** The Global Ionosphere Thermosphere Model (GITM) is pushing the envelope in what is possible for models of the near-Earth space environment. It has a flexible grid, the ability to be driven by many different electrodynamics models, and does not assume a hydrostatic equilibrium solution. We have recently won a proposal to make the grid more flexible, so the grid cells do not get infinitely small near the poles and have been funded to couple it with other synergistic models that have similar flexibility. Our goal is to make GITM a model that can be used and developed by the entire community.
- **Predicting the medium range space weather in the near-Earth space environment using ensemble simulations.** The ionosphere and thermosphere are strongly driven systems, meaning that if you don't know the drivers, it is quite difficult to determine what the system is going to do. This research is focused on better understanding the uncertainties in predicting the drivers and using ensembles to provide a range of solutions. GITM and our satellite propagator are being used in a couple of projects to improve our ability to specify satellite locations and prevent them from colliding with space debris. In many ways, this is a high-risk, high-reward research area, since it could greatly improve our Nation's ability to predict space weather if it works. We are actively working on getting funding to assist in this effort.
- **Measuring the thermospheric and ionospheric state using distributed arrays of instruments.** Working with a variety of researchers across the community, we are attempting to determine how we could improve our understanding of and ability to predict the geospace environment using ground-based measurements from across the country and the world.
- **Using constellations of satellites to better understand our environment.** Typically, NASA has funded very large satellites that carry many different instruments that are all relatively heavy and complex. We have been attempting to push NASA and the Department of Defense to utilize many smaller satellites that have less complex instruments on them instead. This provides many different benefits including redundancy, ease of descoping missions and reduced cost due to building the same component multiple times.

Publications and scholarly presentations

In this section, all graduate and undergraduate students are underlined, while *post doctoral researchers are in italics*.

Full articles in refereed publications

1. Brandt, D. A., & Ridley, A. J. (2022). Statistical characterization of GITM thermospheric horizontal winds in comparison to GOCE estimations. *Space Weather*, 20, e2021SW002922. https://doi.org/10.1029/2021SW002922
2. Gong, F., Yu, Y., Cao, J., Wei, Y., Gao, J., Li, H., et al. (2022). Simulating the solar wind-magnetosphere interaction during the Matuyama-Brunhes paleomagnetic reversal. *Geophysical Research Letters*, 49, e2021GL097340. https://doi.org/10.1029/2021GL097340
3. Malhotra, G., Ridley, A. J., & Jones, M. (2022). Impacts of lower thermospheric atomic oxygen and dynamics on the thermospheric semiannual oscillation using GITM and WACCM-X. *Journal of Geophysical Research: Space Physics*, 127, e2021JA029320. https://doi.org/10.1029/2021JA029320
4. Carter, J. A., Samsonov, A. A., Milan, S. E., Branduardi-Raymont, G., Ridley, A. J., Paxton, L. J., et al. (2021). Field-aligned current during an interval of B_Y-dominated interplanetary-field; modeled-to-observed comparisons. *Journal of Geophysical Research: Space Physics*, 126, e2021JA029722. https://doi.org/10.1029/2021JA029722
5. Bussy-Virat, Charles D, Ridley, Aaron J. (2021), Estimation of the thermospheric density using ephemerides of the CYGNSS and Swarm constellations, *Journal of Atmospheric and Solar-Terrestrial Physics, Volume 221*, https://doi.org/10.1016/j.jastp.2021.105687.
6. Boudouridis, A., Connor, H. K., Lummerzheim, D., Ridley, A. J., & Zesta, E. (2021). Changes in the magnetic field topology and the dayside/nightside reconnection rates in response to a solar wind dynamic pressure front: A case study. *Journal of Geophysical Research: Space Physics*, 126, e2020JA028768. https://doi.org/10.1029/2020JA028768
7. Pulkkinen, T., T. I. Gombosi, A. J. Ridley, G. Toth, and S. Zou (2021), The Space Weather Modeling Framework goes open access, *Eos, 102*, https://doi.org/10.1029/2021EO158300. Published on 13 May 2021.
8. Wu, C., Ridley, A. J., DeJong, A. D., & Paxton, L. J. (2021). FTA: A Feature Tracking Empirical Model of Auroral Precipitation. *Space Weather*, 19, e2020SW002629. https://doi.org/10.1029/2020SW002629
9. Brandt, D. A., *Bussy-Virat, C. D*., and **Ridley, A. J**. (2020). A simple method for correcting empirical model densities during geomagnetic storms using satellite orbit data. *Space Weather*, 18, e2020SW002565. https://doi.org/10.1029/2020SW002565
10. Mukhopadhyay, A., Welling, D. T., Liemohn, M. W., **Ridley, A. J**., Chakraborty, S., & Anderson, B. J. (2020). Conductance Model for Extreme Events: Impact of auroral conductance on space weather forecasts. *Space Weather*, 18, e2020SW002551. https://doi.org/10.1029/2020SW002551
11. Malhotra, G., **Ridley, A. J**., Marsh, D. R., Wu, C., Paxton, L. J., & Mlynczak, M. G. (2020). Impacts of lower thermospheric atomic oxygen on thermospheric dynamics and composition using the global ionosphere thermosphere model. *Journal of Geophysical Research: Space Physics*, 125, e2020JA027877. https://doi.org/10.1029/2020JA027877
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Refereed conference or symposium proceedings papers

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2. Ruf, C., *Bussy-Virat, C*., McKague, D., **Ridley, A.**, Morris, M. (2018), Enabling Sampling Properties of the CYGNSS Satellite Constellation, IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium, 22-27 July 2018, Valencia, Spain, doi:10.1109/IGARSS.2018.8518454.
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5. <u>K. Agarwal</u>, <u>A. A. Ali</u>, A. M. D'Amato, A. J. Ridley, and D. S. Bernstein, "Retrospective-Cost-Based Adaptive State Estimation and Input Reconstruction for the Global Ionosphere-Thermosphere Model," AIAA Guid. Nav. Contr. Conf., Minneapolis, MN, August 2012.
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24. K. G. Powell, T. I. Gombosi, Q. F. Stout, D. L. de Zeeuw, G. Tóth, I. V. Sokolov, A. J. Ridley, K. C. Hansen, W. B. Manchester, and I. I. Roussev, Parallel Adaptive Solution of the MHD Equations and Its Role in the Space-Weather Modeling Framework, in Numerical Modeling of Space Plasma Flows, edited by G. P. Zank and N. V. Pogorelov, *Astronomical Society of the Pacific Conference Series, 359*, 33, 2006.
25. S. Gillijns, O. Barrero Mendoza, J. Chandrasekar, B. De Moor, D. S. Bernstein, and **A. Ridley**, What Is the Ensemble Kalman Filter and How Well Does it Work?, *Proc. Amer. Contr. Conf.*, pp. 4448–4453, Minneapolis, MN, June 2006.
26. I. Kim, J. Chandrasekar, **A. Ridley**, and D. S. Bernstein, "Data Assimilation Using the Global Ionosphere-Thermosphere Model," *Proc. ICCS*, pp. 489–496, Reading, UK, May 2006.
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29. H. Palanthandalam-Madapusi, **A. J. Ridley**, and D. S. Bernstein, Identification and Prediction of Ionospheric Dynamics Using a Hammerstein-Wiener Model with Radial Basis Functions, *Proc. Amer. Contr. Conf.*, Portland, OR, pp. 5052–5057, June 2005.
30. H. Palanthandalam-Madapusi, D. S. Bernstein, and **A. J. Ridley**, Subspace Identification of Periodically Switching Hammerstein-Wiener Models for Magnetospheric Dynamics, *Proc. 14th IFAC Symposium on System Identification*, pp. 535–540, Newcastle, Australia, March 2006.
31. J. Chandrasekar, O. Barrero, **A. J. Ridley**, D. S. Bernstein, and De Moor, State Estimation for Linearized MHD Flow, *Proc. Conf. Dec. Contr.*, pp. 2584-2589, Paradise Island, The Bahamas, December 2004.
32. H. Palanthandalam-Madapusi, S. Gillijns, **A. J. Ridley**, and D. S. Bernstein, Electric Potential Estimation with Line-of-Sight Measurements Using Basis Function Optimization, *Proc. Conf. Dec. Contr.*, pp. 3625-3630, Paradise Island, The Bahamas, December 2004.
33. T.I. Gombosi, D.L. De Zeeuw, K.G. Powell, **A.J. Ridley**, I.V. Sokolov, Q.F. Stout, and

34. G. Tóth, Adaptive Mesh Refinement MHD for Global Space Weather Simulations, in "*Space Plasma Simulation*", edited by J. Büchner, C. T. Dum, M. Scholer, *Lecture Notes in Physics*, *615*, 251-279, Springer, Berlin-Heidelberg-New York, 2003.

Invited Keynote Presentation and Seminars

1. **A.J. Ridley**, The Difficulty With Getting People to Mars… and Back, Astronomy on Tap, Ann Arbor, MI, November 12, 2019.
2. **A.J. Ridley**, The History of Going to the Moon and the Future of Going to Mars, Henry Ford, Dearborn, MI, July 22, 2019.
3. **A.J. Ridley**, *Migration to Mars Panel*, International Student Forum in Trondheim, Norway, February 12, 2019.
4. **A.J. Ridley**, *Modelling the Upper Atmospheric Reaction to Energy Input*, Boston University, November 1, 2018.
5. **A.J. Ridley**, *How do we get to Mars?*, Astronomy at the Beach, Ann Arbor, MI, September 14-15, 2018.
6. **A.J. Ridley**, E. Doornbos, I. Cnossen, and H. Wang, Thermosphere-Ionosphere-Magnetosphere Modeling and Validation Efforts Using SWARM (Keynote), CHAMP, and GOCE Measurements, Fourth Swarm Science Meeting, Banff, Alberta, Canada, March 20-24, 2017.
7. **A.J. Ridley**, *Up, Up and Away! Adventures in Ballooning at UM!*, CEDAR Dinner, Seattle, WA, June 22, 2014.
8. **A.J. Ridley**, *Ballooning at the University of Michigan*, Adler Planetarium, Chicago, IL, July 6, 2009.
9. **A.J. Ridley**, *Interhemispheric Asymmetries*, Center for Space Physics, Boston University, May 21, 2009.
10. **A.J. Ridley**, *Improvements and Uses of the Space Weather Modeling Framework*, Air Force Research Laboratory, May 14, 2009.
11. **A.J. Ridley**, *Adventures in Modeling the Thermosphere, Ionosphere and Magnetosphere*, National Center for Atmospheric Research, January 9, 2008.
12. **A.J. Ridley**, *Extreme Space Weather*, Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, January 23, 2004.
13. **A.J. Ridley**, *The Ionosphere/Thermosphere as an Interactive Boundary in the BATS-R-US Global MHD Code*, Center for Space Physics, Boston University, January 22, 2004.
14. **A.J. Ridley**, *Ionospheric control of magnetospheric dynamics: How the ionospheric con- ductance, neutral winds, and outflow effect the magnetosphere*, High Altitude Observatory, NCAR, Boulder, Colorado, September 19, 2001.
15. **A.J. Ridley**, *High-Latitude Ionospheric Convection* Los Alamos National Labs, Los Alamos, New Mexico, February 2, 1999.

Invited presentations

1. **A.J. Ridley**, Strengths and Limitations in Modeling of the Ionosphere Thermosphere System During Extreme Events, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.
2. **A.J. Ridley**, Allison N Jaynes, Using New Technologies for the Next Generation of NASA Missions, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.
3. **Ridley, A.J.**; Exploring how temporal and spatial variability of energy inputs affect the thermospheric state (Invited), American Geophysical Union, Fall Meeting, Washington DC, 10-14 Dec., 2018.
4. **A.J. Ridley** and E. Donovan, *Socratic Dialogue 2: Models and Observations: How to fill the gaps?*, CEDAR Student Workshop, Sante Fe, NM, June 24, 2018.
5. **A.J. Ridley**, S. Zou, The effects of small-scale structures on the state of the thermosphere and ionosphere (Invited), American Geophysical Union, Fall Meeting, New Orleans, Louisiana, 11-15 Dec., 2017.
6. D. P. Drob, J. Huba, L. Kordella, G. D. Earle, **A. J. Ridley**, The great American solar eclipse of August 21, 2017; new understanding of the response of the upper atmosphere and ionosphere. (Invited), American Geophysical Union, Fall Meeting, New Orleans, Louisiana, 11-15 Dec., 2017.
7. **A.J. Ridley**, *The Global Ionosphere Thermosphere Model*, CEDAR Student Workshop, Keystone, CO, June 18, 2017.
8. Sazykin, S., Coster, A., Huba, J., **Ridley, A.**, Erickson, P., Foster, J., Baker, J., Wolf, R., Dynamics of Subauroral Polarization Stream (SAPS) Structures (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-18 Dec., 2015.
9. **Ridley, A.**, Interhemispheric Differences in the Upper Atmosphere (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-18 Dec., 2015.

10. **Ridley, A**., The Role of High Latitude Drivers in Accurately Modeling the Thermospheric and Ionospheric Response to Geomagnetic Storms (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-18 Dec., 2015.
11. Harding, B., Makela, J., Meriwether, J., **Ridley, A**., Thermospheric Wind Response to Geomagnetic Activity: Observations of the Doppler Shift of 630.0-nm Airglow (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-18 Dec., 2015.
12. **Ridley, A**.; Makela, J.; Meriwether, J.; Conde, M.; Noto, J.; Thayer, J., The Synergistic Relationship Between Networks of Instruments and Global Models, American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-19 Dec., 2014.
13. Meriwether, J.; Makela, J.; **Ridley, A**., Measurements of Thermospheric Winds and Temperatures with a Fabry-Perot Interferometer Network: Results from NATION, South America, and Alaska, American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-19 Dec., 2014.
14. **Ridley, A.**; Ruf, C.; Posselt, D.; Rose, R.; Provost, D., The strengths of constellation missions when exploring our atmosphere, American Geophysical Union, Fall Meeting, San Francisco, Calif., 14-19 Dec., 2014.
15. **Ridley, A. J**.; Zhu, J., Exploring the Sources of Acoustic and Gravity Waves in the Thermosphere (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 9-13 Dec., 2013.
16. Zou, S.; **Ridley, A. J**.; Moldwin, M.; Nicolls, M. J.; Coster, A. J.; Thomas, E. G.; Ruohoniemi, J., Multi-instrument Observations of Storm Enhanced Density (SED) During the Oct. 24-25 2011 Storm: Implications for SED Formation Processes (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 9-13 Dec., 2013.
17. **Ridley, A. J**.; Pawlowski, D. J., Understanding the Uncertainties in the Lower Thermosphere and Their Effects on the Structure of the Atmosphere (Invited), American Geophysical Union, Fall Meeting, San Francisco, Calif., 9-13 Dec., 2013.
18. Pawlowski, D J, Bougher, S W, **Ridley, A J**, Murphy, J R, Modeling the Martian Upper Atmosphere Using the Mars Global Ionosphere-Thermosphere Model (Invited), 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
19. Gombosi, T I, Toth, G , van der Holst, B , Sokolov, I , Manchester, W B, Daldorff, L , DeZeeuw, D , Welling, D T, **Ridley, A J**, Liemohn, M W, Oran, R , Meng, X , Jin, M , New Adventures with the Space Weather Modeling Framework (Invited), 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
20. **Ridley, A J**, Ruf, C S, Rose, R , Scherrer, J , The Cyclone Global Navigation Satellite System: An 8-Satellite Constellation Mission (Invited), 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
21. Ruf, C S, Gleason, S , Jelenak, Z , Katzberg, S J, **Ridley, A J**, Rose, R , Scherrer, J , Zavorotny, V , The NASA EV-2 CYGNSS Small Satellite Constellation Mission (Invited), 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
22. Zou, S., Moldwin, M., Nicolls, M.J., **Ridley, A. J.**, Coster, A. J., Yizengaw, E., Lyons, L. R., Donovan, E., Electrodynamics of the high-latitude trough: Its relationship with convection flows and field-aligned currents (Invited), 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
23. Deng, Y, Fuller-Rowell, T J, Knipp, D J, **Ridley, A J**, Significance of Poynting flux and soft particle precipitation to the cusp neutral density enhancement (Invited), 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec., 2011.
24. **Ridley, A J**, Zhu, J, Yigit, E, Drob, D P, Conde, M G, Pawlowski, D J, The Importance of Large-Scale Wind Measurements (Invited), 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec., 2011.
25. **A.J. Ridley** Y. Yu, M. W. Liemohn, A. M. Dodger, Understanding the geoeffective properties of rapid changes in the solar wind and interplanetary magnetic field (Invited), *2010 AGU Fall Meeting*, San Francisco, CA, December 13-17, 2010.
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1. Brandon Ponder, **Aaron J Ridley**, Ankit Goel and Dennis S Bernstein, Adaptive Estimation of Thermal Conductivity Coefficients in the Global Ionosphere Thermosphere Model, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.
2. Charles Bussy-Virat, **Aaron J Ridley**, Estimating the thermospheric density from the GPS measured trajectories of the CYGNSS satellites, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.
3. Daniel Brandt, Charles Bussy-Virat, **Aaron J Ridley**, Investigating Storm-Driven Thermospheric Density Enhancements with Two-Line Element Sets and Orbital Propagation, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.
4. Garima Malhotra, **Aaron J Ridley**, Daniel Robert Marsh, Chen Wu, Larry J Paxton, Understanding the Effects of Earth's Lower Atmosphere on Upper Ionospheric-Thermospheric Semi Annual Oscillation - Using GITM, MSIS and WACCM-X, AGU Fall Meeting, San Francisco, CA, Dec. 9-13, 2019.

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13. Zou, S; Ozturk, DS; Coppeans, T; Ren, J; Wang, Z; Ridley, AJ; Impact of Sudden Solar Wind Dynamic Pressure Variations on the Geospace System, American Geophysical Union, Fall Meeting, Washington DC, 10-14 Dec., 2018.
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