Ryan D. Torn: Candidate’s description of individual and co-authored work

My research involves collaboration with both graduate students and external collaborators; therefore, a majority of my publications have one or more co-authors. For these papers, I employ the following co-authorship guidelines, which are consistent with the standards used in the larger atmospheric science community. For most of these papers, the order of the authors reflects the amount of effort put forth by each of the co-authors. In most cases, I encourage graduate students to be the lead author, so he/she can receive maximum recognition for the work carried out under my supervision (papers with a * on the CV). It is worth noting that having graduate students write papers involves more effort than if I were to write the paper myself because teaching a student how to write a scientific paper can require significant time and mentoring. Four of my papers either summarize field campaigns that I have participated in (Montgomery et al. 2011; Weisman et al. 2015), a community software package that I contributed to (Anderson et al. 2009), or are a review article on a specific topic (Keller et al. 2017). In those instances, the list of authors is alphabetical for authors that contributed equally.
Ryan D. Torn Research Statement

Nearly all weather forecasts are based on output from numerical weather prediction (NWP) models. These models consist of the equations of motion for the atmosphere and a number of approximations for small-scale processes to generate predictions starting with the current state of the atmosphere (i.e., initial conditions). Unfortunately, the atmosphere is an example of a chaotic system, meaning that errors in the initial conditions, or how the model represents specific atmospheric processes can increase in size over time, which in turn will yield a forecast without value as the forecast goes further out in time. As a consequence, it is important to understand what are the sources of error within the model, how these errors amplify with time, what are the processes that cause the rapid error growth, how error growth varies for different atmospheric phenomena, and developing strategies for overcoming the limits of predictability. To that end, I have developed an international reputation as an expert in atmospheric predictability and dynamics (i.e., motion) for a variety of features. Much of the research within my group takes advantage of statistical relationships determined from large sets of NWP forecasts initialized at the same time (i.e., ensemble forecasts) to test specific hypotheses about atmospheric predictability. I have been the PI for numerous federal research grants to support this work, including four from the National Science Foundation (NSF) and three from the National Oceanographic and Atmospheric Administration (NOAA) where I was the PI or co-PI. In addition, I have acted as a co-Investigator on five other grants from the same agencies. To this date, I maintain active collaborations with scientists at multiple Universities, government labs, and operational forecasting centers.

Tropical cyclones (TCs) are one of the costliest natural disasters in terms of life and property; therefore, it is important to produce accurate forecasts of their track and intensity (i.e., maximum wind speed), and understand the processes that govern the predictability of these metrics. By evaluating ensemble forecasts of TC genesis (formation) and intensity change, my group has identified two main sensitivities for TC intensity forecasts: the structure of the wind field, such that more symmetric wind field early in the forecast is associated with a more intense TC later in the forecast, and the amount of water vapor in the mid-troposphere (approximately 3-6 km above the ground), such that higher water vapor early in the forecast is associated with a more intense TC later in the forecast (e.g., Torn and Cook 2012; Rios-Berrios et al. 2016a; Rios-Berrios et al. 2016b). These sensitivities are proxies for the efficiency of convection (i.e., thunderstorms) in spinning up the TC circulation. The atmosphere is not the only potential source of uncertainty that might be important for TC intensity forecasting. Torn (2016) compared how the uncertainty in the initial-time atmosphere and ocean evolves into TC intensity variability later in the forecast for a variety of TCs. One of the intriguing results from this study is that 3 day TC intensity forecast uncertainty is the same when initializing forecasts with atmosphere uncertainty or ocean uncertainty, which indicates that our TC ensemble prediction systems need to account for both atmosphere and ocean uncertainty (this is the subject of NOAA award NA16NWS4680025).
Torn et al. (2015), we documented how uncertainty associated with convection roughly 500 km to the north of Hurricane Sandy led to some forecasts indicating a westward turn toward the New Jersey coast, while other forecasts had Sandy moving eastward out to sea. Since then, we have identified multiple instances with large TC track variability and found that the largest position forecast sensitivity is not due to uncertainty in the motion of large-scale features, but is instead related to small differences in the near-storm wind field during the first few hours of the forecast. These wind differences cause the TC to move into different sides of the wind “saddle” point (Torn et al. 2018).

Another one of the main contributions of my group to TC research has been in the area of data assimilation, which is the process of creating initial conditions for a model that combines observations with a previous forecast in a way that accounts for the errors in each. My group was one of the first to use ensemble-based methods for assimilating observations near TCs, which is potentially advantageous for TC forecasting because this approach does not make overly-restrictive assumptions for how observations should be incorporated into the model. This technique was applied to a single case (Hurricane Katrina, 2005; Torn and Hakim 2009a) and for a larger number of cases both in a retrospective (Torn 2010c) and a real-time forecasting mode (Cavallo et al. 2012). In addition, we employed the output from these data assimilation systems to demonstrate how this information could be used to diagnose model biases. For example, Torn and Davis (2012) found that proper treatment of trade wind cumulus clouds in the tropics is necessary to obtain accurate TC steering wind forecasts. Finally, I have applied ensemble-based methods to diagnose optimal locations to obtain “targeted” observations that could improve TC genesis forecasts (Torn 2014). These methods were subsequently applied to TC track and intensity forecasts during the 2015-2016 NOAA Sensing Hazards with Operational Unmanned Technology (SHOUT) program in, which used an unmanned aerial vehicle to obtain observations near TCs.

One of the other major foci of my research has been on the origin of forecast uncertainty in the midlatitude regions (typically between 30-60°N), particularly when TCs interact with the jet stream. In Torn and Hakim (2015), we showed that TCs moving into the midlatitudes can create a similar response in the midlatitude jet stream as ordinary winter cyclones (i.e., storms). The biggest difference between these two features is that TCs can amplify the midlatitude jet by themselves, while winter cyclones amplify an upstream pre-existing feature. Torn (2017) extended this work by comparing the downstream predictability associated with TCs moving into the midlatitudes with winter cyclones. The results indicated that the TCs entering the midlatitudes are a source of uncertainty that quickly spreads downstream, particularly for forecasts initialized prior to the TC entering the midlatitudes. By contrast, strong winter midlatitude cyclones have a more limited downstream impact. In Lamberson et al. (2016), we evaluated the source of errors associated with a significant European cyclone from 2011 (named Joaquin). In that study, we traced the errors in this cyclone to uncertainty in the sub-synoptic features (< 500 km in scale) within the midlatitude jet stream in the Gulf of Alaska seven days earlier. These errors subsequently moved eastward along
the midlatitude jet during the forecast, resulting in subtle timing differences between a feature moving out of the Arctic and a cyclone that tried to develop off the east coast of the United States. The forecast uncertainty originates from a region commonly referred to as a warm conveyor belt, which is a feature that transports warm, moist air northward and is associated with significant rainfall and latent heat release. The focus of one of my current NSF awards (1461753) is on quantifying the sensitivity of downstream forecasts to the uncertainty in various aspects of warm conveyor belts; the results will be presented in Berman and Torn (2018).

During 2013, I was one of the key participants in the Mesoscale Predictability Experiment (MPEX), which had a goal to test the hypothesis that decreasing the uncertainty in upstream sub-synoptic features during the morning would lead to better forecasts of severe convection later in the day. My contribution to this project was to compute the sensitivity of convective forecasts from a set of high-resolution ensemble forecasts, which could be used to guide the Gulfstream-V aircraft flight plans during the experiment, and study the processes that lead to convection forecast uncertainty. Over multiple case studies, which spanned different large-scale regimes and geographical locations, we found that forecasts of severe convection are most sensitive to waves that form along strong moisture boundaries (i.e., the dryline; Torn and Romine 2015; Torn et al. 2017; Berman et al. 2017). These waves modulate the position of the boundaries, yielding different environments from which convection can be initiated. One of the intriguing aspects of this study was that several different types of features were responsible for creating these waves, including tropopause-based synoptic troughs, sub-synoptic midtropospheric waves, and even convection from the previous day. Although we tried to deploy the aircraft in regions of large convection forecast sensitivity, Romine et al. (2016) found that assimilating this extra data did not always improve the forecast, likely due to a combination of not completely sampling the region of greatest sensitivity and model formulation errors.

Going forward, there are a number of research directions that I would like to pursue related to the dynamics and predictability of the atmosphere. I would like to continue to investigate the predictability of TC intensity, and in particular under what conditions is intensity less predictable. Preliminary results suggest that TC intensity is less predictable before a TC undergoes intensification within marginal large-scale environments; however, additional analysis is required before publication. In addition, much of the focus on TC impacts is typically on wind, while rainfall and storm surge are typically given less attention. In turn, we know little about the predictability of these aspects of TCs; therefore, I would like to address this problem using ensemble forecasting and sensitivity analysis. While most of my work has focused on the role of initial condition uncertainty on predictability, there is growing evidence that uncertainty associated with physical processes, especially cloud microphysics and sub-gridscale mixing parameterizations, can have a substantial impact on forecasts of TCs and convection. To that end, I plan to expand my research portfolio in that direction, including through a current NSF Partnerships for International Research and Education (PIRE) award (1545917), which is looking at how the uncertainty in physical
processes limit the predictability of heavy rainfall. Finally, most weather prediction models are
trending toward becoming coupled systems that include models that permit time-evolving ocean
and sea ice states. As a consequence, I would like to investigate how various components of these
coupled systems impact the predictability of atmospheric features; this type of investigation is part
of a proposal to understand the predictability of Arctic cyclones, which is currently under review
with the Office of Naval Research (ONR).
Ryan D. Torn Teaching Statement

During my tenure at the University at Albany, I have taught both undergraduate (ATM 410, 418) and graduate courses (ATM 511, 562, 652). For each of these courses, my goal is to provide students with an appreciation for the fundamental processes that govern how the atmosphere works, so they can use this concepts in future classes, or in their career. As a consequence, I stress critical analysis skills within my homework and exams. I have adopted a traditional teaching approach, where I lecture using a dry-erase board and employ technology when appropriate. One of the advantages to teaching atmospheric science is the ease in finding visual examples of the ideas taught in lecture; thus, I typically reinforce concepts by incorporating both real-time and historical data into my lectures. Although some students have requested that I make notes available before class, my experience suggests that this approach has little benefit because it allows the students to be “lazy” listeners and note takers. Moreover, I believe students are more likely to understand a concept if the instructor takes the time to provide all of the details and assumptions that go into a derivation because the concepts are often limited by what is assumed. Even though I have taken a mainly traditional approach, I also incorporate alternative teaching strategies into my course design and lectures, which are documented below. My goal in assigning homework is to give students the chance to practice applying the concepts learned in the lecture. In addition, I view exams the opportunity for the students to demonstrate their mastery of the material by answering a mix of short answer questions that someone taking notes in the class could answer, and more difficult questions that force the students to employ critical thinking skills that tie together several different ideas. As a consequence, my exams are often characterized by a large range of grades, which acts to identify the stronger students. Finally, I see teaching as a continually-evolving process; therefore, I have consistently attended ITLAL seminars and have tinkered with my courses to improve student outcomes.

From 2009-2011, I taught ATM 410 (Dynamic Meteorology I), which provided an opportunity to experiment with new teaching methods and observe the results. The purpose of this course is to derive the fundamental laws that govern motions in the atmosphere and provide a foundation from which future courses can draw upon. In my opinion, it is one of the most difficult courses to teach in the Atmospheric Science major because the material tends to be more abstract than other courses in the major; therefore, it can be difficult to obtain real world examples of the concepts. Secondly, the course relies heavily on calculus-based physics, which is a challenge for students with weak quantitative skills. To address the first challenge, I added a new topic to the course on how numerical weather prediction models use the equations derived in class, which helped demonstrate the applicability of course material to real-world problems. For the latter challenge, I have made a number of modifications to my teaching style, which include spending more time emphasizing the physical meaning behind each mathematical term. During the last time I taught the course (Fall 2011), I split the class into groups at the beginning of the semester, whereby
each group was responsible for providing a verbal summary of the previous lecture on a rotating basis. My goal for this activity was to force the students to take responsibility for reviewing the material after each lecture. The grades for this activity were assigned based on feedback from other members of the group. I am proud that the overall instructor score for this course improved from a 3.6 my first year (Fall 2009), to 4.6 during the next two years. These higher scores coincided with the changes I made to the course and are on par with other quantitative courses offered by the department.

Starting in Fall 2013, I have developed and taught ATM 418 (Dynamic Meteorology III), which was added to the Atmospheric Science B.S. curriculum in response to student feedback. The goal of this course is to understand the physics associated with fronts, mountains, thunderstorms, and the boundary layer. One of the biggest challenges with this course is that students are very interested in thunderstorms, but not as interested in the other topics. Most of my lectures build upon information provided in previous lectures; therefore, I have employed several methods to encourage students to review their notes daily. From 2013-2014, I employed the same group summary strategy from ATM 410; however, I quickly realized this approach had become ineffective. In response, I experimented with giving daily two-question quizzes based on material from the previous lecture. The questions are not difficult, so long as the students understand the basic concepts from the previous lecture. The students have responded positively to this change, with comments like “Quizzes at the beginning of every class was a successful way of preparing for class. Classes ran smoother as a result.”. My overall instructor rating exceeded 4.0 for each iteration of this course, with two semesters above a 4.8.

During semesters where I have not taught an undergraduate course, I have taught three different graduate courses, ATM 511 (Synoptic-Dynamic Meteorology II; Spring 2009, 2011, 2013-2017), ATM 562 (Numerical Weather Prediction; Spring 2010, 2012) or ATM 652 (Atmospheric Predictability; Fall 2012). Similar to the undergraduate courses above, I like to emphasize how conceptual models being taught during the lecture can be used to understand actual weather events; this approach has been applauded by students in all three classes. For each of these classes, the final grade is weighted toward a student’s performance on projects that apply the abstract concepts from lecture into a more tangible, real-world application. These types of assignments allow the student to take more ownership for learning the material and provide a superior method to reinforce the concepts from the lecture compared to traditional problem-solving assignments. Some of the projects are self-guided, meaning that I provide the steps needed to do the project and expect the students to interpret the results. Other projects are open-ended, meaning that I allow the students to develop their own project, which can be an offshoot of the student’s thesis research. The independent projects from ATM 562 and 652 subsequently resulted in four M.S. theses. My course evaluations suggest that the students appreciate how I teach these particular courses; my overall instructor ratings are at or near 5.0 for all graduate courses. Although ATM 511 is an elective, at least 50% of all students took the course from 2013-2017. Student comments from Spring 2016
and 2017 include: “This is by far the best class I have ever taken in my schooling career. Dr. Torn is a highly skilled professor who knows how to communicate complicated topics in a simple and efficient manner.” and “Honestly, the best professor I’ve ever had. Ryan is so amazingly-effective at communicating whatever he is teaching, whether it be a simple topic or a very complex theory.”

While classroom teaching is an important part of a university education, mentoring research at all levels is an equally-important and rewarding activity. I have been the academic advisor for approximately 7 Atmospheric or Environmental Science majors per year and I have mentored four undergraduate research projects over the past five years. In each situation, I have tried to give the student the latitude to develop and execute the project, while providing enough guidance to prevent the student from veering too far off course. Gabriel Susca-Lopata’s undergraduate honors thesis won both the Bazzoni Fellowship and the President’s Award for Undergraduate Research and he went onto earn a M.S. in Atmospheric Sciences at the University of Utah.

On the graduate side, I have been the sole advisor for six students (Rosimar Rios-Berrios, Travis Elless, Jeremy Berman, Meghan Conway, Kevin Lupo, David Cook) and co-adviser of four others (Philippe Papin, Bill Lamberson, Molly Smith, and Jannetta Richardson). Mentoring graduate students extends beyond helping them to produce high-quality research. I consistently stress the importance of developing good oral and written communication skills as well as ability to critically evaluate research results and develop new research questions. This is accomplished through weekly group meetings, where I encourage students to provide constructive feedback to each other following informal presentations. I hold my students to high standards and train them to be their own biggest critic, so that potential reviewer concerns are addressed by the time they submit a paper for publication. To date, I have published seven papers with students and have five others in review or preparation. In most situations, I encourage students to be the lead author and mentor them on developing a logical argument and scientific writing skills. In addition, I provide my students with a variety of opportunities to establish their own reputation in the field by engaging in visitor programs at national labs and traveling to numerous conferences to present their work. Students who graduate from my group are in high demand; all four students who have graduated with M.S. and Ph.D. degrees from my group have been hired into degree-appropriate positions prior to graduation. Finally, I have served on 30 Ph.D. or M.S. committees, five of which are for students at other universities (Stony Brook University, University of Miami, University of Oklahoma, and University of Washington).

Going forward, I would like to teach a wider variety of undergraduate courses, including the lower division general education courses offered by DAES. These classes are an opportunity to enhance science appreciation within the diverse UAlbany student population, though success will undoubtedly require employing new teaching strategies. In addition, I will continue to provide research opportunities for undergraduate students and mentor between 3-5 graduate students at one time.
Ryan D. Torn Service Statement

The primary goals of my service activities have been to help build a world-class graduate program within the Department of Atmospheric and Environmental Sciences (DAES), assist in University-related committees in areas where I can make the biggest contribution, and provide my expertise within my discipline. I excel in service activities which require active participation among all participants and where attention to detail is critical. In addition, I have risen to leadership positions in multiple service activities based on my past effort.

Starting in Fall 2013, I have been the DAES Graduate Program Chair. One of my first orders of business within this position was to establish a required core curriculum. During this process, the graduate committee and I surveyed peer institutions, and worked with other faculty members to develop a curriculum that served everyone’s interest. The resulting changes were put into place for the Fall 2015 semester. In addition, the graduate committee undertook a top-to-bottom review of all graduate program policies to make sure all current policies were still appropriate and identify any gaps. During my time in this position, the DAES graduate program grew from 54 to a high of 86 students; therefore, I have undertaken steps to make the program run more smoothly. This includes developing a formal graduate program guide (which his updated yearly), establishing formal protocols for various aspects of the program, coordinating skills seminars for first-year students, streamlining communication with graduate studies and staff, and developing a set of yearly procedures that my successor can use. Going forward, my main goals for the committee will be to develop interdisciplinary degree options in coordination with other departments, including a Weather and Climate MBA, combined B.S./M.S. programs with other relevant programs (e.g., College of Emergency Preparedness, Homeland Security and Cybersecurity), and certificates or badges that will help our graduate students to be more attractive in the labor market.

In addition to my graduate program duties, I have made other contributions to the department. For the last four years, I have been a member of the DAES committee that assisted in the design of the new Emerging Technology and Entrepreneurship Complex (ETEC) building. The members of this committee have been tasked with developing a DAES “wish list” for the new building and iterating on multiple versions of building and room schematics. This has been a critical, yet rewarding activity because this building is meant to serve future generations DAES faculty and students; therefore, it is important to be detail-oriented and forward-thinking with the design. Previous department activities include being the co-organizer of the DAES-Atmospheric Sciences Research Center (ASRC) Joint Seminar Series during 2009-2012. In that role, I was responsible for soliciting requests for speakers, making sure the program is balanced among various research areas and organizing speaker visits when necessary. From 2011-2013, I was on the DAES undergraduate committee, which resulted in the modification in both of the department B.S. degrees to meet trends within each field and respond to student feedback. Finally, I served on two faculty search committees, and chairing one that resulted in hiring two people during the 2012/2013 academic
Since being promoted to Associate Professor in Fall 2014, I have expanded my University-wide service activities in a number of ways. I have been an active member of the Undergraduate Committee on Academic Standing since 2012. This committee meets for 35-40 hours per semester and hears appeals related to dropping courses, waiving graduation requirements, readmission and dismissals. I have found this activity rewarding because it has allowed me to interact with a broad group of campus colleagues, learn more about other programs, and understand the unique challenges faced by some UAlbany students. Although faculty are typically on the committee for one year and often rotate off, I have been asked by the Dean of Undergraduate Studies to remain on the committee each year. During the Spring 2015 semester, I was asked by Dean Kevin Williams to serve on a committee tasked with assessing graduate student stipend rates, which subsequently produced a report designed to make the university more attractive to prospective graduate students. As part of my duties, I reached out to other UAlbany STEM departments for their ideas, and provided feedback to Dean Williams, including stipend rates from peer departments. During 2017, I was actively involved in the University Strategic Planning process in two different areas. For the Spring 2017 Roadmaps, I helped to develop the set of action items to enhance UAlbany’s graduate programs, which included a recommendation for more interdisciplinary degrees. When the Strategic Planning process was restarted in Fall 2017, I was asked to contribute to the Research Excellence subgroup, which is currently developing concrete action items that will strengthen the University’s research portfolio. Finally, I have participated in a number of short-term service requests, including as a panel member for multiple STEM graduate student career development workshops (Forum for Students in the Master’s programs and B.A./M.A. (B.S./M.A.) combined programs; Doctoral Student Discussion Forum for the Sciences), and reviewing Phi Beta Kappa applications (each semester).

My professional service has typically made use of my research expertise and has evolved into multiple leadership positions. Starting in 2008, I served as an associate editor for two of the most prestigious journals in the atmospheric science field: *Monthly Weather Review* and *Weather and Forecasting*. This service requires reviewing 6-10 manuscripts per journal per year and providing a quick turn-around on controversial papers. Peer-review is one of the hallmarks science; therefore, I take great responsibility in preparing my reviews. For my efforts in this area, I was awarded one of the American Meteorological Society Editors Awards in 2011 for “providing thorough and timely reviews of numerous manuscripts for both journals”. In 2016, my record as a reviewer resulted in my promotion to Editor, meaning that I am now required to find reviewers and make decisions on roughly 50 papers per year. This can be a very time-consuming activity, yet it is vital to the peer review process. Twice per year, I travel to the National Center for Atmospheric Research (NCAR) to serve on their High-Performance Computing Advisory Panel (CHAP). A typical meeting is divided into two parts: providing advice on how NCAR’s computing division can better serve the university community and reviewing roughly 50 proposals for resources on
the NCAR supercomputers. At times, the latter task has proved to be a challenge because the requests can exceed 500% of the available time, yet we are obligated to provide at least some resources to everyone who has a NSF grant. During this process, I have taken great care to provide a fair allocation of resources, such that good proposals are given more time, rather than applying an across-the-board cut to all projects. My active participation resulted in a promotion to chair starting in Spring 2017, meaning I am responsible for assigning reviews to each panel member, and coming up with the final recommendation during the panel meeting.

In 2011, I was appointed to the United States The Observing System Research and Predictability Experiment (THORPEX) Science Steering Committee, which was responsible for setting research priorities in the area of atmospheric predictability. While the committee was not very active for the two years I was a member (it was dissolved at the end of 2013), I helped co-organize a workshop in Washington, DC in September 2012, which brought together 25 atmospheric and social scientists to discuss problems of mutual interest and collaboration. In recognition of my expertise in ensemble forecasting, I was asked to be a co-Chair of the NOAA Next Generation Global Prediction System (NGGPS) Strategic Implementation Plan (SIP) group for ensemble forecasting in 2017. This group recently finished compiling a set of action items that will bring the next generation modeling system online.

Finally, I have tried to engage the broader community to educate them about the science. For five years, I was a member of the American Meteorological Society DataStreme Local Implementation Team, which involved acting as a mentor to local teachers who work through a 12 week course on one of three topics (Water in the Earth System, Atmosphere, or Earth’s Climate System), and developing a plan to use the information and resources from the course within their classroom. I found this to be a rewarding service activity because it provides teachers with the knowledge to inspire the next generation of scientists, which are in short supply within this country. Since then, I participated in the New York State Master Teacher selection (August 2016). On three occasions, I have been asked to give public lectures, two on Earth’s climate and another on weather forecasting. These talks are challenging to prepare because the audience often has a limited scientific background; therefore, the material must be presented at a level that everyone can understand, yet still remain true to the science. As a consequence, my philosophy for these lectures is to provide the audience with foundational information, so that they can retain the main points, and if desired, can seek out additional information. Finally, I have made numerous media appearances, including local television and nationally-syndicated radio shows, which has allowed me to use my expertise to inform the public and act as an ambassador for UAlbany. Going forward, I would like to expand upon my community service activities because I believe it is the responsibility of every scientist to teach others about the importance and relevance of science.