Providing better support for entrepreneurial activities in the weather, water, and climate community

Keith L. Seitter,[a] Emma Tipton,[a] Paul A.T. Higgins[a]

[a] *American Meteorological Society, Boston, MA*

Corresponding author: Keith L. Seitter, kseitter@ametsoc.org

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ABSTRACT

There has been an increase in entrepreneurial activity within the weather, water, and climate (WWC) community over the past decade, with the potential for much more as artificial intelligence/machine learning techniques continue to develop and as new opportunities arise across the weather, climate services, and ocean services enterprises. Despite indications of recent growth, this study reports on key challenges that are limiting the community's ability to achieve the full potential of commercialization of new WWC products and services. Most of these challenges are related to the preparation of those in the WWC community for jobs in the private sector in general, and entrepreneurial activities in particular. These results extend and build upon the work of others who have reported on shortcomings in the preparation of students for positions in the private sector, with this study showing that deficits in preparation and awareness of available resources affect potential entrepreneurs well into their career — most researchers are unaware of the resources available to them. Based on a synthesis of input from successful WWC entrepreneurs, many of the challenges could be greatly reduced by relatively minor adjustments to curriculums at universities and through new programs that could be offered by scientific and professional societies to help potential entrepreneurs better take advantage of existing resources as they spin up a new business.

SIGNIFICANCE STATEMENT

This study examined the challenges faced by those seeking to engage in entrepreneurial activity to take innovative ideas toward commercialization as new products or services related to weather, climate, or the oceans. We found that many researchers in the geosciences lack adequate preparation to make the transition to entrepreneur. Moreover, preparation at the university level has great influence over student readiness for careers in the private sector, in general, and entrepreneurial careers in particular. We suggest relatively minor adjustments that could be made to university curriculums, as well as modest programs that could be implemented by scientific and professional societies that could greatly reduce the challenges currently experienced by potential entrepreneurs working in the disciplines covering weather, water, and climate.

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The path to entrepreneurship for those in the weather, water, and climate community could be made easier through some relatively minor adjustments that address common challenges.

The recent expansion of initiatives supporting scientific innovation relating to the Earth system suggests that there is great potential for new ideas and entrepreneurial activity within the geosciences to have a significant impact throughout society. Accordingly, it is a prime opportunity for the geoscience fields to consider how their communities' expertise may most effectively link to innovation and entrepreneurship endeavors. The AMS Policy Program recently completed a rapid study looking at the challenges and opportunities for increasing entrepreneurship in the geosciences (Seitter et al. 2023), with a primary focus on the weather, water, and climate enterprise (AMS 2023). The study solicited input from members of the AMS community, including students and early-career professionals as well as those later in their careers. The study benefitted from many informal discussions with professionals from the community, and there were 23 individuals who participated in more in-depth virtual discussions. While the majority of participants belonged to the private sector, the perspectives of government employees and academic researchers were also sought to learn more about how innovations coming from these sectors can be commercialized through entrepreneurial activities. We lay out a selection of insights gained from these discussions here but would note that the full report (Seitter et al. 2023) provides additional information on some of the challenges that are only briefly mentioned here.

Findings

There is widespread agreement within the AMS community that there is a great deal of potential for innovation and entrepreneurial growth in the weather, water, and climate (WWC) space. While the weather enterprise, with a robust private sector, has been well established for many years (NOAA Science Advisory Board 2021), it has seen a surge in innovation as technological advances, such as more sophisticated artificial intelligence and machine learning (AI/ML) techniques, are incorporated. Additionally, while for many years the primary focus within the community was on getting the forecast right, that focus is increasingly shifting toward using improvements in forecasting capabilities to address societal problems. This, in turn, has opened up a wealth of opportunities for new products and

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services that meet the needs of businesses and the general population. Innovation has not been limited to the weather enterprise—recent years have seen nearly explosive growth in private sector companies providing climate services across a range of applications in the United States and globally (see, e.g., NOAA Climate Program Office 2023; Ten Hoeve 2022; Perrels 2019). Additional private sector growth is emerging in areas such as the ocean enterprise [sometimes referred to as the New Blue Economy (Spinrad 2016)] and space weather applications and services.

Although opportunities for innovation and entrepreneurship abound, conversations with entrepreneurs and researchers within the AMS community also revealed several prevalent challenges that may present barriers to these opportunities being widely realized. The findings presented here highlight issues associated with the preparation of students for entrepreneurial careers, difficulties researchers experience when trying take innovative ideas to commercial success, and challenges entrepreneurs face when trying to achieve long-term success. Beyond that, there are several additional areas that, while not necessarily challenges to overcome, should be accounted for accordingly to effectively cultivate a vibrant entrepreneurial environment within the WWC enterprise, and the geosciences as a whole.

The challenge of academic preparation for the private sector in general and entrepreneurial activities in particular

While there is no single path to business success, there are nonetheless certain skillsets and foundational knowledge that may facilitate an idea's journey to commercialization. Many current WWC entrepreneurs, however, report having had no background or academic training in business prior to founding their company. This is not surprising as it is uncommon for undergraduate or graduate programs in the atmospheric and related sciences to include business-related coursework, such as finance or report writing, in their already packed curricula (nor would it necessarily make sense for them to do so). A lack of business-related skills that would be useful for employment in the private sector is well-documented. Surveys

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of early career professionals from the AMS Mind the Gap committee[1] have shown that many feel they did not learn what they needed to successfully enter the private sector from their meteorological degree program. Indeed, key findings coming from the two Mind the Gap workshops[2] highlight the desirability for changes in academic curriculums to both make students more aware of private sector opportunities and better prepare them for employment in that sector.

Simply adding business coursework to existing degree programs is likely not a substantial solution to this issue. Academic institutions generally have involved processes for amending curriculum core courses or requirements, and piling on additional requirements without removing other courses is unsustainable for both students and faculty (Tipton et al. 2021). Moreover, a strong foundation of scientific and technical knowledge is a key component of successful innovation. As such, a handful of business courses in a science curriculum may not be as valuable for enabling future innovation as courses that build in-depth technical knowledge. An exception to this may be courses that focus on communications; whether used in conveying information to customers, investors, other scientists, or the general public, communications skills are considered to be highly transferable across sectors and situations (Tipton 2023). It is therefore almost certain that the inclusion of science communications courses, or at a minimum, building greater general communication skills, both oral and written, through projects in existing courses, would benefit any science curriculum regardless of whether students go on to become entrepreneurs.

While adding business-related courses to a program's curriculum is not generally an option, students should be made aware of options they can pursue if they are looking to move into entrepreneurship. For example, some foundational business management knowledge

[1] See https://www.ametsoc.org/index.cfm/cwwce/committees/ad-hoc-mind-the-gap-committee/.

[2] See https://ral.ucar.edu/events/2019/mind-the-gap and https://www.atmos.albany.edu/facstaff/andrea/MindTheGap/MindTheGap2.html

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may be gained through dedicated short-term training programs offered through a variety of institutions such as venture schools or local business development centers, as well as some online offerings. However, these kinds of programs may be difficult to find, be accepted into, or afford.

As the potential for AI to provide new products and services expands, new opportunities for entrepreneurial activities that are built on AI expand as well. This disruptive technology will require a new and differently trained workforce. Having a portion of the total workforce with deep knowledge of the underlying science will still be critical, but the training for the bulk of those working in the weather community may need to be very different, and university curriculums will need to respond rapidly to this changing world.

Additionally, issues dealing with intellectual property (IP) came up in many discussions in this project. It was felt that all students should be taught what IP is, how policies vary among universities, government, and private sector, and that IP issues need to be considered carefully and addressed comprehensively. It is unlikely that an entrepreneur will be able to successfully raise venture capital funding, for instance, if funders feel that ownership of the IP is not clear.

The study identified a range of other important issues related to academic preparation of students for private sector positions. Again, consistent with findings of the Mind the Gap workshops, this study found that many are not aware of the wide range of career options in the private sector, including entrepreneurial opportunities. In discussions, community members consistently mentioned that both students and faculty are largely not exposed to career paths outside of research. When the goal of an academic position is assumed to be the default, students who might be interested in entrepreneurship may not choose to pursue this interest because there is little to no guidance on how to succeed on this career path. Another, related point is that graduate students, in particular, may be bound to their (or their advisor's) source of funding and lack the flexibility to explore work that does not pertain to that funding. Further, there are additional challenges for international students, who may not be able to take on certain kinds of work without violating the terms of their visa.

The challenge of aligning incentives and opportunities to the needs of WWC entrepreneurs

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The progression of an idea from conceptualization to successful commercialization can be a long and complex process, particularly for those new to entrepreneurship. While there are a number of existing opportunities relating to funding, training, and other forms of entrepreneurial support, these opportunities may be difficult to access. Moreover, the needs of WWC businesses are often highly specific in a way that makes finding appropriate support challenging. A more widespread understanding of the current entrepreneurial landscape may help geoscience entrepreneurs to realize their goals effectively. The brief descriptions below highlight some of the key programs available to those launching entrepreneurial efforts.

SBIR/STTR

The federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grant programs[3] are a central component of the entrepreneurial landscape across the sciences. Participating federal agencies each have their own SBIR program office and accept proposals from small businesses relating to designated research and development (R&D) topics. These awards are critically important funding sources for those starting a small business as an entrepreneur. Moreover, for companies that later choose to pursue venture capital (VC) funding, having obtained SBIR or STTR funding can confer an advantage by demonstrating to investors that the company has shown the technical capability to obtain a SBIR/STTR grant.

While the SBIR program is a key mechanism to reduce risks for innovation, there are some challenges with the SBIR program that represent structural issues. To secure a grant, a team needs to include members with extensive academic credentials (typically Ph.D.s). However, the commercialization process is different from scientific research, and making the transition from an academic research mindset to a commercial mindset can be very difficult. It is also noteworthy that each federal agency in the SBIR program differs in review criteria and agency thrust. For example, there is a sense that NSF tends to give greater weight to ideas that have high return potential, while NOAA is not as concerned with that if the idea

[3] See https://www.sbir.gov.

furthers its mission. This is seen by many as both a strength of the various SBIR/STTR programs and a challenge. Without guidance from consultants or other experience in the proposal process, it is hard to know which agency to apply to or how to structure the proposal for that agency. This leads to innovators with excellent ideas sometimes needing to submit multiple proposals before the idea is funded—having learned from the reviews of failed proposals how the proposal should have been structured from the start. Moreover, individuals from certain socially or economically disadvantaged backgrounds are less likely to resubmit proposals after a rejection, which presents a challenge to achieving greater inclusivity in the program. The number of applications for SBIR programs have increased dramatically over the past five years, while funding for the programs has not, leading to lower success rates that can discourage those with innovative ideas from seeking SBIR funding.

I-Corps

Another opportunity at the federal level is the NSF I-Corps program[4], a training program for those pursuing entrepreneurial activities. Several participants in this study praised the I-Corps program for its approach to teaching scientists how to pitch their ideas effectively. NSF's "Beat-the-Odds Bootcamp"[5] is a noteworthy component associated with the I-Corps program.

University incubators and venture programs

It is common for universities to have programs intended to support faculty or students with ideas that might be viable for commercialization. These can take many forms, and faculty or students with an idea that may be viable for commercialization should see what forms of support may be available at their university in addition to the other resources discussed here (for example, some states have programs covering all schools in the state system[6]). Spinning up start-ups in the biomedical world has become relatively commonplace,

[4] See https://new.nsf.gov/funding/initiatives/i-corps.

[5] See https://seedfund.nsf.gov/resources/awardees/phase-1/bootcamp/.

[6] See: https://www.passhe.edu/offices/asa/startup-challenge/index.html

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and the resources developed at universities in support of biomedical start-ups may be available to researchers (faculty and students) in the WWC community to help make the transition from research result to commercial business.

Federal Laboratory Consortium for Technology Transfer and Cooperative Research and Development Agreements

In contrast to research faculty at academic institutions, researchers at government facilities have limited opportunities to pursue outside entrepreneurship if a research idea has potential commercial value. There are, however, examples of innovations created by government labs that were subsequently licensed to the private sector for further development and distribution, such as the Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys (Lawson 2016). The Federal Laboratory Consortium for Technology Transfer (FLC), a network of over 300 government organizations with the mission of accelerating the path of federal technologies to the marketplace, helps facilitate these kinds of activities.[7] There are also many examples of using a Cooperative Research and Development Agreement (CRADA) between a federal lab and a private sector company to commercialize products and services developed in the federal lab. In general, commercialization of hardware has been more successful when a federal agency secures a patent and provides a license for the IP, as compared to an "open science" approach in which a private sector company may invest resources into developing the hardware and then have the market collapse when competitors copy their product. However, there is a sense that the "open science" and especially "open data" approaches of agencies can be beneficial for the development of new software products.

Commercial investment

Beyond SBIR or STTR funding, it can be very hard for WWC entrepreneurs to obtain the resources needed to fully complete the commercialization of an innovation. For the most part, commercial incubators focus on ideas that are likely to provide large returns on investment.

[7] See:https://federallabs.org/

They are less likely to support projects that might have important value to humanity but show much less potential for large returns on investment. Similarly, venture capital and angel investors are often not interested in products that have modest return potential even though they may be excellent from a public good standpoint. To these investors, the projects are seen as “passion projects” rather than money-making opportunities. This represents a challenge in the geosciences, since many important innovative projects are not likely to meet the threshold of investment return sought by commercial investors. There is little doubt, based on even the limited number of participants in this study, that this investment challenge has delayed successful commercialization in the WWC community.

Recommendations

Given the findings of this study, there are some clear recommendations that can be made to address the key challenges. These recommendations are being made by the authors and do not carry the endorsement of the American Meteorological Society. Indeed, some of these recommendations are aimed at AMS and its sister societies that serve the WWC community.

University curricula

Truly addressing some of the education and training issues to better prepare students for entrepreneurial careers will require changes in curricula and new resources that are not likely to happen quickly or easily. Of all the findings, those related to adequately preparing students for careers in the private sector—while keeping other career path options open to them at the same time—are the most challenging, and we can perhaps offer only first step recommendations. An emphasis should be placed on exposing students to career paths that are in the private sector and especially those with entrepreneurial characteristics, such as consulting. University programs should include for all students some training in communicating to a range of audiences (which is useful regardless of their career path). These recommendations are all consistent with findings from the Mind the Gap workshops. Some training on IP issues so that every student is aware of the basics is also useful regardless of the career path. Universities also need to adjust the curriculums to better train the workforce needed for a future in which AI/ML drives a lot of the products and services in the weather, water, and climate enterprises.

Training and development opportunities

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There should not be an attempt to try to turn every entrepreneurial scientist into an engineer or CEO. A better path would be to provide training for the scientist so that they understand what a company needs and know how to find the right people to do those jobs. There are professionals who make a career path of helping start-ups get established successfully, so the scientist needs to be equipped with the knowledge of how to seek out these people and find a good match for the company being established. Even if these professionals have no domain-specific knowledge, they still know what a company needs to operate and how to scale up a product toward commercialization. Among the approaches that could be pursued are the following.

Entrepreneurial fellowships

A possible approach would be to have a funded fellowship program, perhaps through NSF or other agencies under the umbrella of their SBIR programs, focused on entrepreneurship and aimed at researchers with ideas that have potential for commercialization. The fellowship could fund the researcher to embed in an existing company and work with that company to develop their idea, with the matchmaking accomplished through some sort of competitive process. The companies would compete to receive a funded researcher for some period and the chance to potentially develop a new product, while the researcher would receive real world experience and develop skills that might yield new innovations later.

Workshops and bootcamps

In noting that many students are not far enough along in their thinking to recognize that they might want to pursue specifically an entrepreneurial path (even if they are thinking of a career in the private sector), several study participants suggested intensive training programs. With some modest external support, such programs could be hosted by organizations like AMS. These programs could provide entrepreneurial bootcamps of a day to a few days to provide participants with the base level of knowledge needed to be ready to take advantage of the many other resources available at the state and federal level for those seeking to start a business. These workshops could focus mostly on providing extensive information on how to most effectively take advantage of existing programs (I-Corps, SBIR, STTR, state and local small business support, etc.), rather than reproduce them.

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A set of separate, but related workshops or bootcamps should be established that are geared toward entrepreneurs in the geosciences and that provide the basic information needed to start a company. These should cover the most foundational elements at the very basic practical level of how you set up a company, get insurance, establish accounting practices, etc. (that is, more foundational than existing programs like I-Corps). These could be offered as virtual courses given the small and distributed nature of potential entrepreneurs, or perhaps done in conjunction with the annual meetings of relevant societies (like AMS).

Mini-grant and competition programs

University programs that do not already have such a program should implement small, competitive, mini-grant (around $2K) programs that would allow students to pursue taking a research idea toward applications. If external funding were available, organizations like AMS could also administer modest small grant programs to help students learn more about the process of moving research ideas toward application. Other forms of competitive programs, such as hackathons, can be very effective in engaging students in efforts that expose them to the sort of creative innovation that leads to entrepreneurship. Programs like these, in addition to the sorts of training recommended elsewhere in this report, could increase the awareness of students to entrepreneurial career paths.

Another option to create space for researchers to explore ideas is innovation challenge competitions. U.S. funding agencies could explore emulating the European Union's Climate KIC program[8], which offers a possible model to support applied innovation with some flexibility, with dedicated mechanisms to support new idea creation as well as help to get workable ideas funded.

Formalized information exchange

The findings of this study make it clear that a key element in improving entrepreneurship in the WWC community is providing both students and researchers with more information on how they can take their ideas toward commercialization. For example, some university

[8] See https://www.climate-kic.org/.

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researchers have ideas that could be commercialized but the researcher does not have an interest in pursuing that opportunity. In some cases, the researcher may not be aware of a potential market or avenues that they could pursue with their idea. Meanwhile, there are entrepreneurs who would be well placed to develop the idea if they were aware of it. This suggests that some sort of formalized information exchange through which researchers could share possible ideas with entrepreneurs, who can then follow up with the researchers to collaborate in commercialization.

A component of any formalized program that links researchers with potential entrepreneurs should be training for the researchers that covers how to navigate the licensing process in addition to helping to find entrepreneurs to develop their idea. A formal network can then be established that can match the ideas coming from academic researchers with entrepreneurs who will license them for commercial development.

AMS (and other organizations like it) offer one avenue to establish such programs. Even something like a "speed dating" session at an annual meeting that brings together researchers with ideas and entrepreneurs with experience moving an idea to product could be immensely valuable provided guidelines could be established to ensure the propriety of researchers' ideas.

Conclusions

There is innovation and entrepreneurship across a broad spectrum of activities within the WWC community from new instrumentation for observations to new analysis techniques to new applications software aimed at decision-makers. The input received from community members throughout this study highlights the rapid pace of development as well as several areas where action could be taken to further enable entrepreneurial activity. The full report explores several of these areas in greater detail.

Key takeaways:

- There are many programs at the federal, state, and regional level that can be utilized to support entrepreneurial activities, but many individuals in the WWC community are not aware of the wealth of resources available to them. Modest changes in

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university curricula and new programs by scientific and professional societies could effectively raise awareness of these opportunities.

- Many researchers lack adequate preparation to make the transition to entrepreneur. There is a need for additional training to gain these needed skill sets, which includes knowing when to seek outside expertise.
- In some cases, the most effective path to commercialization is connecting a researcher with a new idea with an entrepreneur who can take it to commercialization. There are examples of successful matching programs that could be emulated by universities and scientific and professional societies with a high likelihood of success.

The recommendations provided here provide specific actions that can be taken within university programs serving the WWC community and by relevant scientific and professional societies to address key challenges for increasing successful entrepreneurial activities and for better preparing students to enter the private sector workforce.

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Data Availability Statement.

Data sharing is not applicable. No datasets were generated or analyzed during the current study.

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