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1. INTRODUCTION

It has been over a decade since the last study of undergraduate meteorology enrollments and degree recipients was published. Using degree data through 1993, Mass (1996) posed the question, "Are We Graduating Too Many Atmospheric Scientists?" Since that time, numerous developments have profoundly altered the meteorological world and significantly raised its visibility with the general public, requiring a re-examination of Mass's question. Examples include:

- The May 1996 release of the film *Twister*, a popularization of stormchasing that grossed nearly a quarter-billion dollars at the U.S. box office (<http://imdb.com/boxoffice/alltimegross>);
- The development of the World Wide Web, creating new industries and leading to instant worldwide access to meteorological information;
- The evolution of mainstream media into niche markets, including the expansion of weather-related vendors (e.g., The Weather Channel) and nature-related cable networks offering weather entertainment as a staple of their programming; and
- The rise of weather and climate topics to prominence in national and world affairs, from global warming and the 1997-98 El Niño to Hurricane Katrina in 2005 and the co-awarding of the 2007 Nobel Peace Prize to the Intergovernmental Panel on Climate Change (IPCC).

During this same period, anecdotal reports surfaced of rapidly growing undergraduate meteorology programs. Without an update to Mass (1996), however, no definite nationwide conclusions can be drawn from these scattered reports.

Therefore, it seems timely to ask: what have been the trends since 1993 in U.S. meteorology enrollments, in particular the number of degree recipients and their employment prospects in our field? This article seeks to quantify the trends using two independent sources of data: the U.S. Department of Education's National Center for Education Statistics (NCES), and the AMS/

UCAR online database found at the AMS Web site http://ametsoc.org/amsucar_curricula/index.cfm. I also speculate on what these numbers and trends imply about the future for our students and our profession.

2. THE CONTEXT: DEGREE RECIPIENT TRENDS FROM 1968-2004

Before making sense of recent trends in meteorology student numbers, we must first place them in the broader context of long- and short-term trends in higher education. As shown in Table 1, from 1968 to 2004 the number of annual bachelor's degree recipients in the United States more than doubled. During the same period, the number of physical science majors of all types declined 7%. As a result, the percentage of all bachelor's recipients with a degree in the physical sciences plummeted from 3.1% in 1968 to approximately 1.3% in 2004. In the geosciences, a category that includes meteorology but whose degree recipient trends are dominated by the solid earth sciences (e.g., geology), the number of bachelor's recipients increased 83% between 1968-2004. This trend, however, masks a rollercoaster of soaring gains until the mid-1980s, followed by a precipitous decline in geology and then a slow recovery. The discipline of geography, which includes a meteorological component in the specialty of physical geography, has experienced trends similar to the solid earth sciences (though with less volatility). Meteorology's sister science of oceanography swelled its ranks 164% from 1968-2004, but dropped 31% from 1994-2004 to near 35-year lows.

TABLE 1: NCES Data for U.S. College Degree Recipients in:	Long- Term Change 1968-2004	Recent Change 1994-2004
All fields	+122%	+20%
Physical sciences	-7%	-2%
Geosciences	+83%	+9%
Geography	+74%	+3%
Oceanography	+164%	-31%
Meteorology	+161%	+47%

By contrast, the number of meteorology bachelor's recipients increased 161% from 1968-2004, and 47% from 1994-2004. The change between 2002 and 2004 was nearly 16%, the largest two-year rise in meteorology degree recipients in this dataset since the mid-1970s. The total number of bachelor's recipients in

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meteorology in the most recent two-year-averaged yearly estimate, 567, is the highest since at least 1963-64 [Figure 1; based on data from NCES and from Orville (1978) as republished in Mass (1996)]. This combination of unprecedented numbers and rapid growth is not mirrored in the graduation statistics of any other related science, nor in the U.S. college graduate population as a whole.

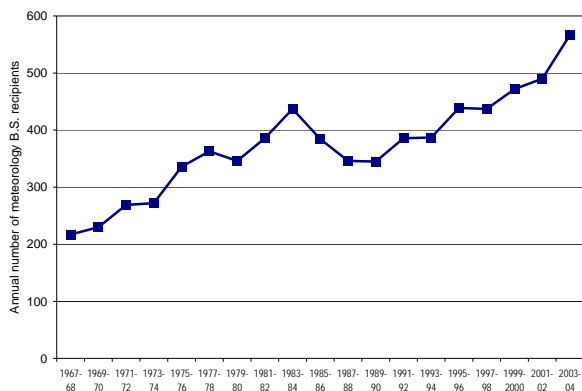


Figure 1. Annual number of meteorology bachelor's degree recipients from 1967-68 to 2003-04, from NCES data as analyzed by the American Institute of Physics.

3. RECENT DEGREE RECIPIENT TRENDS: AMS/UCAR CURRICULA DATA

Past studies (e.g., Mass 1996; Vali et al. 2002) have more often relied on *Curricula* data than on U.S. Department of Education statistics to quantify numbers and trends in degreed meteorologists. The advantages of *Curricula* versus NCES data include timeliness and breadth of information; relevant disadvantages include lack of reporting/misreporting from a number of institutions and the inclusion of non-U.S. and non-meteorology programs.

In the following discussion of online *Curricula* data, I have chosen to omit information provided by Canadian institutions and programs that are overwhelmingly oceanographic in nature (the U.S. Naval Academy, Old Dominion University, the Department of Oceanography at the University of Washington) in order to focus tightly on U.S. meteorology programs. A total of 75 such institutions are included in the online *Curricula* database.

As of 15 April 2007, however, only 34 institutions (45%) had reported the number of bachelor's recipients during the academic years 2003-04 and 2004-05, compared to 59 institutions reporting in the 1994 *Curricula* (Figure 6a in Mass 1996), 53 in the 1998 *Curricula*, and 45 in the 2000 *Curricula* (Vali et al. 2002).

Given the relatively sparse reporting to the online *Curricula*, analysis of the data must be made with some caution and cross-referencing. Mass's data for 1991-93 (Figure 2) is compared to *Curricula* data for 2003-05

(Figure 3) by tabulating the number of degree recipients per institution for the two-year period of 2003-05. Despite 25 fewer institutions reporting online than in the 1994 *Curricula*, the total number of degree recipients is greater: 941 in 2003-05 versus 901 in 1991-93.

A trend toward larger numbers and larger programs seems evident. According to Mass (1996, Figure 6a; republished below as Figure 2), during 1991-93 only six institutions graduated more than 30 meteorologists. As seen in Figure 3, during 2003-05 eleven institutions conferred more than 30 meteorology degrees. Thus, *Curricula* data generally support the conclusion drawn from NCES data that there has been a notable rise in the number of meteorology bachelor's recipients since the early 1990s.

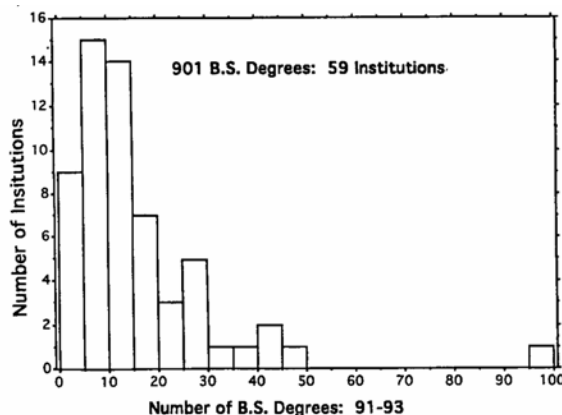


Figure 2. Histogram of meteorology bachelor's degree recipients listed in AMS *Curricula* during 1991-93, from Mass (1996).

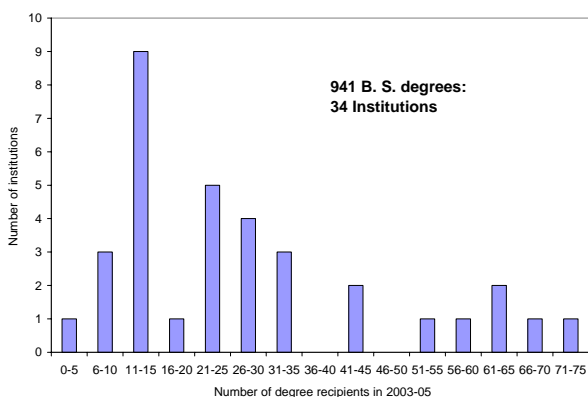


Figure 3. As in Figure 2, but for 2003-05.

We next compare 2003-04 graduation numbers with 2004-05 graduation numbers from the *Curricula*. In the academic year 2003-04, the 34 institutions providing data reported 446 bachelor's recipients; in 2004-05, 495 bachelor's recipients were reported from these same institutions, for a one-year increase of 11%. (Note that the absolute numbers are lower than in NCES data because of the comparatively spotty reporting in the *Curricula* database.) This growth is somewhat larger,

but not incompatible, with the two-year rise of nearly 16% determined from NCES data ending in 2004.

In summary, both NCES and *Curricula* data indicate that from 2001 through 2005 the number of meteorology bachelor's recipients increased at an annual rate of approximately 8-11%.

4. RECENT ENROLLMENT TRENDS FROM THE CURRICULA

A mostly untapped source of demographic information on undergraduate meteorology is the data collected on current undergraduate majors in the *Curricula*. Though labeled "Ethnicity/Gender Profiles," the totals also allow for calculation of the number of meteorology majors enrolled nationally. The number of majors is a less reliable statistic than bachelor's recipients because of sparser reporting, differences in the definition of a meteorology major between different institutions, and errors in reporting (e.g., some institutions report the same number of majors as degree recipients, an unlikely situation). Nevertheless, trends in this statistic may anticipate future trends in meteorology degree recipients.

Despite the absence of many of the largest meteorology programs in the nation from this statistic, the number of majors reported for Fall 2005 by 22 institutions is 2,154, or an average of 98 majors per institution. This represents a 69% increase (just over 9% per year) in majors-per-institution since the 2000 *Curricula*, in which 36 institutions reported 2,091 meteorology majors for Fall 1999. However, this trend is probably a bit of an overestimate due to a relative absence of smaller programs in the online database versus the 2000 *Curricula*.

The online *Curricula* also contains data on the number of meteorology majors for the 2003-04 and 2004-05 academic years. This data can be used to calculate per-year changes in majors. Unfortunately, only 17 institutions appear to have reported accurate majors numbers for all three time periods of 2003-04, 2004-05, and Fall 2005. The one-year upward change in undergraduate meteorology majors based on these 17 institutions was 2%, but the quasi-two-year rise (from the 2003-04 academic year to Fall 2005) was nearly 21%, for an increase of almost 10% per year. This rate of increase, too, may be an overestimate because of attrition during the 2005-06 school year, but it is consistent with the trends found above in degree recipient data. However, this analysis does not include some new and rapidly growing programs, a point addressed below.

5. PROJECTED DEGREE RECIPIENT TRENDS FROM THE CURRICULA

The projected degree information in the *Curricula* provides another untapped data source regarding future degree trends. Institutions reporting to the *Curricula*

estimate their future graduation totals for up to six years into the future. In the aggregate, this data may provide a glimpse, however imperfect, of future graduation trends. As with any forecasts, the shortest-term projections are probably the most accurate.

Forty institutions reported projected degree recipient information three years beyond the Fall 2005 reporting deadline (i.e., 2005-06, 2006-07, and 2007-08). However, only 23 institutions projected graduation numbers all the way out to 2010-11, limiting confidence in the longest-term projections.

The one-year increase in projected degrees (from 2005-06 to 2006-07) obtained from the 40 institutions is 12%, similar to the rates in actual degree recipients discussed above. The two-year change in projected degrees obtained from the 40 institutions approaches 15%, or 7% per year. Using just the 23 institutions who reported projections out to 2010-11 the five-year rise in projected degrees is 28%, or an increase of about 5% per year. Taken together, these results imply a 5-12% per year increase in projected bachelor's degree recipients through 2011.

The agreement between the upward trends across independent datasets and different statistical categories (see Figure 4) provides compelling evidence that meteorology has grown rapidly at the undergraduate level in the United States since Mass's (1996) study. To the extent that the projections discussed here are accurate, this growth—anomalous with respect to the trends in other related sciences and with respect to the previous history of meteorology in the United States—will continue for at least the next several years.

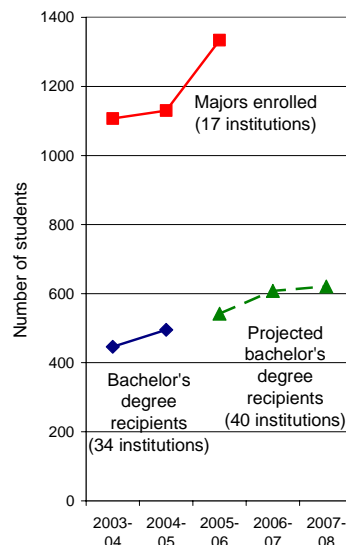


Figure 4. AMS/UCAR *Curricula* data for meteorology majors, degree recipients and projected degree recipients as of 15 April 2007.

¹ The 5% lower bound is the less accurate figure, due to sparse reporting and the extended range of the forecast.

6. RECENT AND FUTURE EMPLOYMENT TRENDS

Is this growth sustainable? To answer this question, we must estimate the demand for meteorologists, and the future growth of that demand.

Approximately 7,400 people in the United States were employed in 2004 as meteorologists, according to the U.S. Department of Labor's Bureau of Labor Statistics (BLS) Occupational Outlook Handbook (OOH; <http://stats.bls.gov/oco/ocos051.htm#outlook>). During 1994-2004, 1.2% annual growth in meteorology employment took place, spanning a period of sizable growth in the late 1990s and downsizing from 1998-2000 (Table 2). The 12% total growth during this period should be compared to the 47% growth in meteorology bachelor's recipients during virtually the same period in NCES data (Table 1). In other words, **during 1994-2004 the growth in demand for meteorologists was approximately four times slower than the growth in the supply of new meteorologists.** This comparison pits growth trends in *all* meteorology jobs versus growth trends in B.S. meteorologists; but given that jobs requiring a B.S. or less education are the majority (see Table 3), it is not an unreasonable comparison.

Year	Number of Employed U.S. Meteorologists (OOH data)
1994	6,600
1996	7,300
1998	8,400
2000	6,900
2002	7,700
2004	7,400

During the same period, AMS *Curricula* data capture a change in the career choices of recent graduates. In 2003-05, over 29% of new bachelor's recipients pursued additional education, as compared to under 20% in 1997-99. Conversely, fewer than 19% of new graduates obtained private sector employment in 2003-05, as compared to nearly 29% in 1997-99. (It should be noted that these are changes in percentages, not absolute numbers. NCES data indicate that the total number of meteorology graduates increased 30% from 1998 to 2004.) The civilian government, once the primary employer of new meteorology graduates, employed fewer than 8% of new graduates in 2003-05, down from 10% in the late 1990s and 50% or more in the early 1970s (Horn et al. 1974).

Did a larger percentage of recent graduates turn to graduate school instead of the private sector in the early-to-mid 2000s because of a lack of employment opportunities? The answer likely depends on the numbers of jobs versus degreed meteorologists.

To assess job numbers, we use the 2006 listings of the *Meteorological Employment Journal*, an online service containing a much more comprehensive list of private-sector and university employment than other sources, with a total of 759 U.S. meteorology positions advertised during 2006. (However, civilian and military government meteorology positions are not generally included in this database and will be discussed separately.) This total is 51% greater than the 500 new job openings found by Mass (1996, Figure 13) for 1993, which *did* include civilian and military positions as well as academic faculty positions. Since the total number of meteorology jobs has risen much less than 51% since 1993 (Table 2), this suggests that the *Meteorology Employment Journal* database is more comprehensive than was Mass's analysis.

Table 3 summarizes the *Meteorological Employment Journal (MEJ)* listings for 2006 in terms of the number of jobs advertised and the educational and professional requirements for each job. At most, 167 positions were determined to be "entry-level," i.e. requiring no experience beyond a bachelor's degree in meteorology.

Period of Record in MEJ	Total U.S. Meteor. Job Listings	Jobs With B.S. Degree Req.	Jobs Without Degree Req.	Entry-level Positions
2006	759	303	132	167

How many entry-level government meteorology positions open up each year? The listings in the NWS Focus (<http://www.nws.noaa.gov/com/nwsfocus>) for 2005-06 show that 105 meteorological interns and technicians have been hired, for an average of 53 new positions per year. These positions may not always be "entry-level" in practice, given the intense competition for NWS employment.

Turning to military employment, Mass (1996) stated that 65 Department of Defense meteorologist positions were available per annum during the early 1990s. This is roughly equal to the number of students reporting "military service" in the online *Curricula* for 2003-05, a two-year sum. Given the underreporting to the *Curricula*, 65 military positions per year appears to be a reasonable estimate.

Summing these statistics, **it appears that currently there are approximately 285 entry-level meteorology positions available in the United States on an annual basis.** This estimate is consistent with the results of Hanson (1993) but is lower than Mass's

(1996, Fig. 13) estimate of 500 new job openings per year during the early 1990s. The lower number determined in this paper reflects more careful elimination of non-entry-level positions from the calculation than in Mass (1996). Most importantly, the estimate of 285 entry-level jobs per year is only half of the 567 meteorology bachelor's recipients per year identified in NCES data.

With regard to job growth, we return to the Occupational Outlook Handbook. The OOH also provides projections of future employment trends (<http://stats.bls.gov/oco/ocos051.htm#outlook>), although these projections are not particularly reliable (R. Czujko 2007, personal communication). With that large caveat, the OOH predicts that from 2004-14 the employment of atmospheric scientists will increase about as fast as the average for all U.S. occupations. The OOH definition of "about as fast as average" equals an increase of 9-17% over that ten-year period, translating to a growth rate of no more than about 1.6% per year.

Comparing this 1.2-1.6% per year actual and projected growth rate in employment to the 5-12% per year actual and projected growth rates in graduates through 2011, the following conclusion seems inescapable, **if the projections are accurate: the number of undergraduate meteorology degree recipients will increasingly exceed the number of meteorology employment opportunities into the next decade.**

Thus, given recent trends and future projections, the growth of the U.S. undergraduate meteorology population is potentially unsustainable in terms of bachelor's-level employment within meteorology.

7. WHAT ARE THE TRUE NUMBERS OF GRADUATES AND STARTING SALARIES?

Over and above the foregoing analysis, the potential exists that there are more meteorology graduates than anyone is aware of—a surplus that may be affecting the pay of entry-level meteorologists.

The large absolute numbers in meteorology bachelor's recipients in the NCES dataset are certainly an underestimate. How much of an underestimate? The Winter 1998 *UCAR Quarterly* (<http://www.ucar.edu/communications/quarterly/winter98/employment.html>), in coverage of the biannual AMS Heads and Chairs Meeting in October 1998, stated that "Colleges and universities are now awarding 600-700 bachelor's degrees in meteorology annually." For this same time period, NCES data placed the number of meteorology bachelor's recipients at 437—a 37-60% underestimate versus the *UCAR Quarterly* figures. Adjusting the latter for the 30% growth rate in bachelor's recipients between 1998 and 2004 in NCES data, this would imply 780-910 meteorology graduates per year by 2003-04. Furthermore, the high end of this estimate, combined with the 11% climb from 2004 to 2005

documented in Section 2, would imply that by 2006 the nation's universities were graduating up to 1,000 meteorologists per year in the United States—numbers unheard-of in the post-World War II era.

How accurate is this estimate? No one knows; the NCES dataset is incomplete, and the online *Curricula* data are even less comprehensive. It is best used as an inexact upper bound. Thus, based on reasonable extrapolations of the data at hand, **the best guess is that there are now between 600 and possibly 1,000 new bachelor's degree recipients in meteorology each year.** Assuming that the estimate of 285 entry-level jobs per year is accurate, this implies that currently there are entry-level positions available for only 28.5-47.5% of new bachelor's recipients in meteorology (assuming that no jobs are filled by non-meteorologists).

Meanwhile, one number that may be overestimated is the pay of a newly degreed meteorologist. One measure of an oversupply of labor is depressed salaries. Table 4 compares starting annual salary data for new bachelor's recipients in a variety of selected majors, from the National Association of Colleges and Employers (NACE) database published in Fall 2006. Meteorology graduates' salaries in this national database are much closer to those in the traditionally glutted and underpaid humanities fields than to salaries for graduates with computer science, physics, geology or mathematics degrees.

TABLE 4:	Class of 2006 Average Starting Salary (NACE)
U.S. College Degree Recipients in:	
Computer Science	\$50,744
Physics	\$45,120
Geology	\$45,091
Mathematics	\$44,672
Chemistry	\$39,804
Meteorology	\$35,211
Environmental Science	\$34,219
Secondary Education	\$33,089
History	\$33,071
Philosophy	\$31,774
Marine Science	\$31,643
English	\$31,385

Moreover, the NACE salary data may be overly optimistic. Widespread anecdotal evidence pegs most starting annual salaries in meteorology at between \$20,000 and \$35,000. On the high end, entry-level National Weather Service employees currently begin at annual salaries ranging between approximately \$26,000-\$32,000, not including the locality pay factor.

However, it cannot be overemphasized that the civilian government is no longer the dominant employer of new bachelor's degree recipients, hiring fewer than 8% of graduates in 2005 and fewer than 10% as far back as 1999. Instead, starting annual salary levels across the discipline are dictated by private-sector employment, where typical entry-level annual pay is currently between \$20,000 and \$26,000 (see also the Winter 1998 *UCAR Quarterly* for specific late-1990s salary information for the private sector). Therefore, the NACE *average* nationwide starting annual salary for just-graduated meteorologists of \$35,211 is difficult to reconcile with the available anecdotal evidence—except in cases where graduates have abandoned meteorology for other forms of employment.

The overall situation for meteorology bachelor's recipients may therefore be worse than official statistics indicate. There are probably more meteorology students than we are aware of, and anecdotal information regarding salaries for new degreed meteorologists is generally lower than publicly stated figures suggest.

8. WHAT SHOULD BE OUR RESPONSE?

Given the recent and likely future growth in meteorology bachelor's degree recipient and enrollment numbers compared to employment possibilities, what should be done by students, faculty, departments and leaders in our field?

Mass (1996) responded to the "deterioration in job availability" in the mid-1990s by calling for a broadening of the meteorology curriculum, honesty on the part of departments regarding the job market, and for an organized effort, perhaps by AMS and/or UCAR, to create an employment database.

These three suggestions are as timely in 2008 as in 1996. I discuss them in turn below.

8.1 A broadened curriculum?

In 1999 the AMS took considerable strides in this regard with its broadened recommendations for a bachelor's degree in atmospheric science (<http://www.ametsoc.org/policy/bachelor99.html>). The new AMS Strategic Plan Goal 5 (AMS 2007) includes the statement that "the Society is also committed to... supporting efforts to develop meaningful curriculum options." Nevertheless, many departments and students alike remain focused on curricula that satisfy Federal civil service requirements, despite the small and shrinking possibilities for civilian government employment.

One possible response is for meteorology programs to make a definitive break with the civil service requirements and tailor their majors to other modes of employment. One appealing possibility would be to train meteorologists for careers in pre-college science

education, which would satisfy AMS Strategic Goal 4 (to create a more scientifically literate population). Given the similarity in NACE starting salaries for meteorologists and secondary school educators (Table 4) and the large market for the latter, an emphasis on training meteorologists as pre-college science teachers would appear to be a win-win-win situation for the discipline of meteorology, undergraduate meteorology majors, and for pre-college education in the United States.

As another alternative, a meteorology major could be reconstituted as a scientific version of a liberal-arts degree, in keeping with the first objective listed in the 1999 AMS recommendations (see Kidder et al. 2002 for a related perspective). For example, at the University of Georgia we offer a multidisciplinary atmospheric science certificate that satisfies both civil service requirements and AMS recommendations but can also be combined with any major. Most of our atmospheric science students choose to major in geography, thereby completing a liberal-arts degree while also obtaining a solid education in meteorology. In addition, some of our students simultaneously pursue certificate work in the highly employable area of geographic information systems (GIS). It would seem that current and future trends in our field call for similar creative educational approaches that emphasize breadth of training and experience.

8.2 Straight talk about jobs and careers?

No one wants to be a "party pooper" when it comes to discussing the possible negative consequences of growth in meteorology. College students enthused about the weather want to major in meteorology. Their parents want them to pursue their career dreams. Faculty members want to recruit more students to their classes and departments. Administrators want more credit-hour production and tuition dollars. Professional organizations want to grow the next generation of scientists. The AMS Strategic Goal 5 regarding recruitment of students calls for increases in effort, activities, funding, and additional development efforts.

The risk of unsustainable growth is real, however. A confluence of events led to a boom in solid earth science majors into the early 1980s, and then a bust by the late 1980s, with only slow recovery thereafter. Meteorology may now face a similar situation. The absence of up-to-date, comprehensive enrollment and employment data from the AMS falls well short of Mass's call for honesty regarding employment opportunities. Discussion and debate of the recent record growth and nearly stagnant employment trends demonstrated in this paper are needed as well.

Also with regard to candor, a common response to the topic of meteorology enrollment and employment is, "There's no guarantee of a job with a meteorology degree! Why should meteorology be any different than, say, English in this regard?" The difference is that

unlike a liberal-arts degree, for decades a bachelor's degree in meteorology usually was a ticket to employment in meteorology, particularly in the National Weather Service (Horn et al. 1974). The message that this is no longer the case does not appear to have been universally disseminated. Instead, meteorology students have attended recent national meetings where talks entitled "Challenging Careers with Opportunities Available: Top Students Like You Needed!" have been presented. The difference between the perception and reality of job prospects appears to be greater in meteorology than in the humanities. If meteorology is to be reconfigured as a liberal-arts degree, this restructuring and the implications for employment must be broadcast widely in professional and academic settings.

One other common rebuttal to concern regarding meteorology enrollment and employment is to claim that a meteorology degree is a fine preparation for a wide range of careers (e.g., Mass 1996). These claims must be supported by quantitative evidence that an education in meteorology is as beneficial as undergraduate training in other disciplines, e.g., physics or mathematics. Math and physics bachelor's recipients receive much higher starting salaries than do meteorologists (Table 4) and are often preferentially recruited by the best atmospheric science graduate departments—both of which suggest that even if meteorology is a beneficial training ground, majoring in another field may be even more beneficial. Assuming that the "good ol' days" of abundant meteorology job opportunities versus the number of meteorology graduates are past, meteorology as a discipline must be able to answer convincingly the following question from students: "Why major in meteorology instead of something else, if I'm increasingly unlikely to have a career in meteorology?"

8.3 Grassroots database efforts?

The results of this article confirm that a comprehensive national database not only of meteorology employment (demand) but also of meteorology enrollments and degree recipients (supply) is desperately needed (see also Pielke, Jr. 2003). Mass's (1996) recommendation that AMS and/or UCAR create an employment database has apparently gone unheeded for a decade. Worse yet, the *Curricula* has declined markedly in comprehensiveness at exactly the moment of greatest growth in meteorology and the greatest need for reliable statistics.

Rather than wait another decade for institutional action, perhaps the swiftest course of action would be for meteorology students nationwide to assemble and update their own "open-source" employment databases. A grassroots effort of this type could also collect information on starting salaries and confirm or reject some of the speculations in this paper regarding pay. Any such database creation needs to be comprehensive, consistent and ongoing, however, so

that reliable long-term data can be accessed. Sporadic, non-standardized individual efforts such as Hanson (1993), Mass (1996) and the current effort described here are inadequate.

8.4 Meteorological "birth control"?

A more polarizing possible response is "birth control," i.e. the intentional limitation of the number of students in a discipline, as in physics at the graduate level during the mid-1990s. Mass (1996) rejected the possibility for meteorology, stating that "one can argue persuasively that there is no need to limit the number of atmospheric sciences/meteorology majors," given that it is a "good base for a variety of careers." Vali and Anthes (2003) were even more emphatic in a response to Pielke, Jr. (2003): "the most responsible position is to look ahead with optimism and to encourage and motivate young people to embark on careers in the sciences, regardless of somebody's prediction of future job opportunities in these fields... the future for atmospheric scientists, although not quantifiable, appears to be very bright indeed..."

In contrast, the quantitative results of this article can be construed to indicate that we have entered a period of chronic oversupply of undergraduate meteorologists. This oversupply has arguably come about because the mechanisms that generate interest in our field (e.g., unprecedented media emphasis on weather) are mostly uncoupled to the mechanisms of demand. Media coverage of weather and climate topics can inspire throngs of students to pursue meteorology as a career; it is specifically cited by faculty at some meteorology programs to explain their swelling numbers. But widespread media attention does not magically create future employment opportunities for these students within meteorology. If, in turn, this situation translates into a future boom in graduate school enrollments and Ph.D. production, the current parlous state of "grantsmanship" in our science as described by the critiques of Carlson (2006) and Roulston (2006) would seem tame by comparison. For those students choosing "out" instead of "up" in meteorology, the sanguine assessment of Mass (1996) regarding the transferability of skills gained from meteorological training would be put to a stringent test.

In the context of this scenario, overt or passive attempts at "birth control" could be a reasonable response to the unprecedented and rapidly growing ranks of undergraduate meteorologists. However, such attempts run counter to the academic rewards system of increased credit-hour production. Any attempt at departmental "birth control," i.e. the limitation of the number of meteorology programs nationwide, would violate the ingrained decentralization of American higher education. Thus, "birth control" appears to be impracticable regardless of one's views on the subject.

9. CONCLUDING REMARKS

Based on the results of this article, ***if current trends in undergraduate meteorology enrollment and employment in the United States continue, there will be far more degreed meteorologists than jobs in meteorology during the next decade.***

It is true, however, that “short-term trends and projections into the future are highly risky” (Vali et al. 2002). The academic and career choices of students are notoriously fluid and unpredictable. Changed political and scientific realities could create professional opportunities unimaginable at present. Predictions of shortfalls and gluts in employment are easily made, but are more rarely verified. For example, the concerns of Mass (1996) and Vali et al. (2002) both seemed dated just a few years after publication, because of changed circumstances in meteorological enrollment and employment. To avoid similar pitfalls, before performing this research I waited seven years after first becoming concerned about an oversupply of undergraduate meteorologists, in an attempt to avoid drawing conclusions biased by short-term cycles or ephemeral “trends.”

Moreover, some of the possible responses detailed in this article, from broadened majors to straight talk about the employment challenges ahead, could go a long way toward preventing nightmare scenarios and creating unforeseen long-term benefits to meteorology—but only if they are implemented. The track record since Mass (1996) is not particularly encouraging in this regard, however.

It is said that we are living in a “Golden Age” of discovery about the earth system, including the atmosphere. In a Golden Age, the Golden Rule must apply: the leaders in meteorology must care for their students as they expect their own sons and daughters to be cared for by the leaders of their chosen professions.

10. ACKNOWLEDGMENTS

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acknowledge my debt to the late Lyle Horn for exemplifying the Golden Rule in his teaching career, and for inspiring my own teaching career. This article is dedicated to my former students who are unemployed, underemployed, or who have left the field of meteorology.

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