1. Introduction
Weather forecasting—is it a science or is it an art? Some of us can easily recall when this was a valid question; indeed, the question is not yet completely laid to rest. For those of us concerned with meteorological education, however, another question has become of much greater practical importance: is weather forecasting a science or is it a profession?

It is, of course, easy to answer this question superficially. We would probably all agree that weather forecasting is both a science and a profession. But further consideration is worthwhile, for this is a question fundamental to the respective roles of universities and of weather services in meteorological education.

2. Basic concepts
First we need to clarify some terminology, obvious as it may seem. The terms “meteorologist” and “weather forecaster” are not synonymous. All weather forecasters are, or certainly should be, meteorologists; but meteorologists engage in many activities other than weather forecasting. I do not know of any universities in the United States which seek specifically to educate weather forecasters. Rather, we seek to educate meteorologists. We do so in the knowledge that many of them, perhaps most of them, will spend a part of their lives, or much of their lives, or even all of their lives as weather forecasters. But we educate them as meteorologists to provide them with maximum career flexibility and maximum opportunity for continued learning.

A second distinction of some importance is that between a “profession” and a “trade.” Inflation of titles being almost as characteristic of our era as the inflation of money, at least in our country, everybody wants to be known as a professional these days. We recognize, however, that the practice of some arts and sciences is based on 1) a background of scholarship, and 2) a wide body of accumulated knowledge which is in a constant state of modification. Those whose daily activities are thus based are in a profession, and weather forecasters are among them. Were this not the case, were weather forecasting a trade, American universities would have no interest in the field.

The problems of education for meteorology as a science and a profession are not unique. Similar situations exist in other fields, and perhaps the health sciences have the closest parallels. For example, consider the field of pharmacy. In this science and profession, we educate for a broad spectrum of activity. Many graduates, especially those with advanced degrees, enter pharmaceutical research. Others, perhaps the clear analogue to the weather forecasters, provide direct services to the consumer as pharmacists in an apothecary. The parallel may be very close indeed; I am told that the individual pharmacist does less and less prescription preparation or chemical mixing of his own, and depends more and more on factory produced items—the factory being his equivalent of the weather central with the big computer.

There is one unique characteristic of meteorological education, however, at least unique in our country: by far most of the graduates go to work for one employer, the United States Government. In pharmacy, or any other parallel one might cite, there is no such concentration of employment. This turns out to be a point of some significance.

3. The differing roles
In pharmacy the particular employer does not expect the graduates to be prepared for a specific job in a defined framework. Rather he expects a graduate well versed in fundamentals, prepared for a lifetime of change and continuing education, and in need of on-the-job exposure to the current routines of the employer. The reverse is sometimes true in meteorology, and we must constantly guard against some pressure for specific job training.

I believe we have done reasonably well in this regard in the United States. In particular, the National Oceanic and Atmospheric Administration (NOAA) and the Air Force have recognized the importance of broad education in the fundamentals of atmospheric science. Traditionally their professional education has been provided at a variety of universities with differing meteorological and educational perspectives, with on-the-job

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1 This paper was prepared for presentation at the World Meteorological Organization’s Symposium on Education and Training in Meteorology and Meteorological Aspects of Environmental Problems, Caracas, Venezuela, February 1975. Any opinions expressed are those of the author and not necessarily those of the U.S. Government.
exposure to routines being better done internally by the employer. I must report that our Navy seems to see the matter somewhat differently, having conducted virtually all of its professional meteorological education internally within the Navy since World War II. I feel that this is a mistake, for the result is a monolithic weather service; given the present state of our science and profession, I believe that a service gains significantly from injection of a variety of educational backgrounds and perspectives toward the discipline.

From what I have said, it must be clear what I (and, I believe, virtually all American educators) envision to be the respective roles of universities and weather services in meteorological education. The university must produce a graduate who is a thoroughly educated scientist at the level appropriate to his degree; who has a mastery of the fundamentals of meteorology and related disciplines; who has the curiosity, the capacity, and the habits of thought which will permit him to grow with his field over the years ahead; who has the ability to apply himself to one or more of the ways in which meteorological knowledge and skill are used for the benefit of mankind; and who has the capacity to earn a living. The weather service, on the other hand, has the responsibility of acquainting the graduate with its policies, procedures, and practices as they happen to exist at the time, and of providing continuous stimuli for professional growth of its personnel.

4. American higher education

While American educators would generally agree on the foregoing, we vary widely in our implementation of this philosophy. For example, one school of thought is that all meteorological education should be postgraduate, based on a bachelor's degree in mathematics or physics with essentially all meteorological work done thereafter; another is that meteorological education should begin early in one's university experience, and that an undergraduate concentration in the subject should be available. You may wonder how two so differing schools of thought can live side by side within the same university system. To understand this, two very basic facts about American higher education must be recognized.

The first fundamental distinction between our higher education system and that in virtually every other nation is that we do not have a central ministry of education as most of you do. As a matter of fact, we do not have a ministry of education at all. We do have a department in our federal government known as Health, Education and Welfare, which encompasses a broad spectrum of programs and within which there is a sub-division which deals with education. This sub-division has three primary functions: 1) data gathering and dissemination, 2) support of educational research, and 3) fund distribution for certain other programs supported by our federal government. In no sense is it a regulatory agency, nor does it prescribe standards for a national system of higher education. Insofar as there are governmentally prescribed standards, and they are virtually non-existent, they are prescribed by the 50 individual states. The world of higher education in the United States basically controls itself, through associations of the universities which set up such standards as are formalized.

The absence of central management results in a wide variation of program details among universities. Each institution, on the basis of maintaining its stature and respect among universities generally, is responsible for developing its own curriculum, maintaining its own standards, and being accredited by a regional consortium of universities. Thus, when a student chooses an institution, he is making a critical choice as to the type of meteorological program in which he will participate.

The second fundamental point about our approach to higher education is that we seek, in every reasonable way, to maximize the freedom of choice for individuals within the system. This is, I suppose, largely a reflection of our social philosophy.

In many national educational systems, a clear separation among students is made at the end of the tenth or some such year; each student is put on a particular track, and there is little if any subsequent opportunity to switch tracks. We operate on a quite different basis. We believe that 16- or 17-year old individuals are not mature enough to make such judgments; some, in fact, do not display their potential until some years later than that. Further, we operate on the assumption that an individual may not know what he really would like to do at that early juncture and ought to have an opportunity to switch from one area to another. Thus we delay irrevocable specialization until the latest practical point, and we make possible a switching from one track to another at almost any point after specialization begins. Actually there is very little specialization through the 14th year of our educational process. The first two years of a university program tend to be quite similar, and only in exceptional cases that a student loses anything of consequence by changing from one area to another as late as the 14th year—by which time he is typically 19 or 20 years old—and, indeed, often he can switch later than that and not lose very much in the process.

This point of philosophy and its implementation, incidentally, have serious implications for the attitude of United States academicians toward the Class I and Class II categorization of personnel as practiced by the World Meteorological Organization. We view the completion of the bachelor of science degree in meteorology as being approximately the equivalent of Class II training, and completion of the master's degree as approximately equal to Class I education. However, and this is the key point, the student must never make a choice that he will be either Class I or Class II. Rather, Class I just means that an individual expands on knowledge acquired for Class II. If the student has the interest and the ability, nothing can stop him from going right
along without losing any time or energy in the process. He need never make an advance decision that he is going to be in one category or the other. He is on a single track, and the question is only where he stops either by choice or by having reached the limits of his capabilities. We find it in principle abhorrent to establish an educational system in which a student must, at a fairly early stage, make a definitive decision to go one way or another. It is for this reason that our attitude has been somewhat negative toward the Class I-Class II distinction.

5. Some suggestions

Returning specifically to the roles of universities and weather services in meteorological education, I do not mean to suggest that relationships between the two are perfect in the United States. Coordination between the two could be significantly improved. As one who has had the rather unusual privilege of serving at fairly high levels of responsibility on both sides, I can see opportunities for improvement.

Relationships between meteorological educators and the government are virtually entirely of an informal kind. This worked rather well when the field was so small that everyone knew everyone else. In the era of the World Weather Watch and the Global Atmospheric Program, we need to work at these relationships. I do not know to what extent the following may be applicable in other nations, but in the United States we should consider these specific steps:

1) Governmental research and operating units should, to the maximum extent practical, be located on university campuses. NOAA has already been a leader in this matter, having placed research or forecasting units on some campuses (for example, the University of Miami and the University of Oklahoma). Students, faculty and governmental personnel all derive intellectual and professional benefits if physical co-location is accompanied by effective interaction. This is a simple mechanism for keeping academicians in touch with the real world and for keeping practitioners in touch with scholars.

2) Formal mechanisms should be established for universities and governmental agencies to engage in continuing discussion and problem solving in meteorological education. The University Corporation for Atmospheric Research, which encompasses the universities concerned, could easily broaden its horizons and take some initiative in this area. The following two points deserve serious attention by a joint university-government group.

3) Opportunities for working experience during the university years should be greatly increased. It has been possible for some meteorology students to work for the government during the summer. This is helpful to the student because it exposes him to field experience and affords him a chance to earn money; it is helpful to the government because it can "sell" itself to the student as a desirable employer and because labor is provided on a temporary basis at relatively low cost. This concept should be expanded to cover more students in the summer and to provide opportunities during the year. It should be possible to alternate periods of work and study on patterns other than the summer one, thereby increasing the benefits inherent in work-study programs.

4) Universities should develop new programs of continuing education, programs which recognize that an individual may only be able to spend a few days, weeks, or months away from his work. We have done very little in meteorology for the individual who cannot come to the university for at least a full term. Universities must become more flexible and must recognize the great importance of once belittled "adult education."

5) Governmental agencies should make increased budgetary and personnel policy provisions for continuing education of their personnel. There has been too much of a tendency to view occasional attendance at scientific meetings, participation in a short course, or a year's scholarship as a benefit to the recipient, as a privilege or a favor. Of course, the recipient benefits; but the agency benefits even more.

We are assembled here because the United Nations recognizes the fundamental role played by education in world peace and development, and because the World Meteorological Organization recognizes that the World Weather Watch and the Global Atmospheric Research Program are critically dependent on meteorological education. We have before us a glorious era in meteorology. The work of generations is coming to fruition in the improvement of weather forecasts, the extension in time of forecasts, and in weather modification. Surely those of us in universities and in government can work together to prepare our colleagues—present and future—to participate productively in this time of great excitement and achievement in our discipline.