The Institute and its role in the development of climate research at the University of Maryland

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1. Introduction

The Institute for Physical Science and Technology (IPST) was established in 1976 as a merger of the Institute for Fluid Dynamics and Applied Mathematics (IFDAM) and the Institute for Molecular Physics. Both Institutes had been established at the University of Maryland shortly after World War II. This article describes how IFDAM also became the origin of major research programs in meteorology culminating in the establishment of a Department of Atmospheric and Ocean Science at the University of Maryland with an emphasis on climate research.

2. Background

In the 1950s a group of meteorologists working at Princeton University under the supervision of mathematician John von Neumann had produced the first large-scale numerical model of the atmosphere using the famous Eniac computer. This group included such notable scholars as Jule Charney, Norman Phillips, George Platzman, George Cressmman, and Joseph Smagorinsky. When this unit disbanded in the mid 1950s, Charney and Philips went to M.I.T., Platzman returned to the University of Chicago, and Cressman became director of the Joint Numerical Weather Prediction unit (JNWP) of several branches of the U.S. Government. Von Neumann brought Joseph Smagorinsky to the University of Maryland where his friend and mathematician, Monroe Martin, was the Director of the already renowned Institute for Fluid Dynamics and Applied Mathematics (IFDAM). Von Neumann introduced Smagorinsky in the hope that IFDAM would also initiate a program of research and development of numerical models of the atmospheric circulation under Smagorinsky's direction.

At that time meteorology was often represented to the public on TV by non-experts reading very brief and inaccurate forecasts, or so it seemed. This image helped perpetuate a feeling, particularly among most "real" scientists, that meteorology was not really a science. Mathematicians were no exception and Monroe Martin, a relatively pure "applied mathematician", could not see a future in mathematical modeling of the atmosphere. So he rejected Smagorinsky who then proceeded to become director of the Weather Bureau's new Geophysical Fluid Dynamics Laboratory (GFDL, now at Princeton) for the development of extended and long-range prediction models. As Smagorinsky told me years later in private, he was "livid" having been rejected by Martin after being promoted and supported by von Neumann. Years later Martin began to realize his mistake.

In 1963 it became apparent that the experimental fluid dynamicist, Francis Hama, would be leaving IFDAM. So Martin sent Professor Shih I. Pai to a conference at the National Center for Atmospheric Research (NCAR) in Boulder, CO, a conference concerned with applications of fluid dynamics in the geophysical sciences. As it so happened I, then a meteorologist/oceanographer at the Woods Hole Oceanographic Institution, was presenting a paper on laboratory studies of the instability of the Ekman boundary layer, and later that spring, apparently at the suggestion of Pai, I was asked to

consider a position as an Associate Professor at the University of Maryland. I joined IFDAM in the fall of 1963. I also was allowed and encouraged to bring with me Robert Kaylor, a graduate student of meteorology from the University of Chicago who had considerable laboratory and computer experience but who was anxious to leave Chicago. Kaylor was a vital part of our research program and of subsequent developments.

3. A Brief Digression to Significant Related Developments

After a few months Monroe Martin asked if I would like to invite someone in the general area of dynamic meteorology to give the annual Spring Public Lecture of IFDAM. I immediately contacted Ed Lorenz, whom I knew personally from M.I.T., and who had just published a remarkable mathematical paper "Deterministic Non-Periodic Flow" (1963). In preparation I mimeographed 100 copies of this paper for distribution to faculty in the Institute and in the Department of Mathematics. There was a modest attendance at the lecture, where Lorenz emphasized the applications of his work to forecasting and to climate modeling rather than his fundamental mathematical results. These eventually became the cornerstone of what is now known as "The Theory of Chaos". As a result of his emphasis at the lecture and in part because of Lorenz' droll manner of speaking his paper and his lecture were largely ignored.

Some years later, shortly after he had become an Assistant Professor, James Yorke brought to me Robert Brammer, a graduate student in mathematics. Brammer was working at NASA on prediction/corrector methods for the flight of spacecraft and thought that he could improve upon meteorological predictions. Lorenz' work on the fundamental limitations of meteorological prediction was the ideal paper to illuminate the new student on the problems of weather prediction. He showed the paper to Jim Yorke, his advisor, who immediately recognized the significance of Lorenz's work and sent copies to several noted mathematicians. In the meantime Yorke and another student had developed a paper entitled "Period Three Implies Chaos". Thus the new science *Chaos* spread throughout the mathematical community and eventually through all aspects of science and human affairs. Some time later Yorke told me that the Lorenz paper was one of the two most important mathematical papers of that year -- published in the Journal of Atmospheric Sciences of all places. Although I had encouraged Brammer to work on an extension of Lorenz's work he chose some other topic for his Ph.D. dissertation. However, years later he became the president of a large meteorological consulting firm in Massachusetts and was once one of two candidates for President of the American Meteorological Society. James Yorke has written several important mathematical papers on Chaos and was recognized by being awarded the Japan Prize in 2003. During the 2000s he has collaborated with faculty in the Department of Atmospheric and Oceanic Science on a major study of the applications of Chaos theory to improvements in the short and extended ranges of atmospheric prediction.

4. Back to Origin of the New Program

About a year after I joined IFDAM, Monroe Martin told me the story of Smagorinsky and said that his rejection was the greatest mistake that he (Martin) had ever made! And then he asked if I would consider setting up a teaching and research program in meteorology in the Institute. Now me having been selected to join IFDAM, the invitation to Lorenz to speak, and the story of Smagorinsky all began to coalesce. After some

considerable thought and trepidation I accepted the challenge.

I first designed a syllabus with three general options: dynamics, physics and chemistry of the atmosphere, and climate. Then I set up a set of course requirements for each option, course descriptions and degree requirements, based largely upon what I knew from MIT and other sources. So a proposal was developed and circulated.

5. Opposition

It soon became apparent that there would be severe opposition from the Geography Department because it owned the climate, and, particularly strong, opposition from Aerospace Engineering because it owned the entire atmosphere. The School of Engineering (in which IFDAM existed at that time) was vigorously opposed to the Institute setting up another teaching program within Engineering in competition for students and research funds. The less conservative and more secure Physics Department, however, already had an option in Upper Atmospheric Physics and was generally in favor of such a proposal. So Monroe Martin, who was well thought of in the university administration, cleverly arranged a "Graduate Committee on Meteorology" consisting of sympathetic deans and department heads. Who could oppose such a committee without very substantial reasons?

In 1965-66, to help ameliorate the bad opinions of engineering faculty toward the Institute, George Mackie, a visiting applied mathematician from Scotland, suggested to me that we organize a joint seminar series with other faculty interested in fluid dynamics. We called it "Fluid Dynamic Reviews", a bi-weekly seminar run by a diverse committee, and before long we had over 20 faculty representing Aerospace, Civil, Mechanical, and Chemical Engineering, Mathematics, the Wind Tunnel, Meteorology, and the Institute, plus students and visitors from the Washington area. Apparently we were successful since it came about that alternate lectures by invited speakers, not from UMD, were supported (travel and an honorarium) by a fund from the College of Engineering. This collaborative seminar series is still in existence.

6. Acceptance of the New Program

I wrote a proposal to the National Science Foundation for a grant to help support such a program, and a second proposal to the University Senate for approval of the program and its courses. Obviously major contributions from Monroe Martin were essential, particularly with the budget, the structure of the program within IFDAM, and within the University. Also, by this time Helmut Landsberg of the Weather Bureau was giving occasional lectures in the Institute, and his experience and advice was reflected in Martin's final versions of these proposals.

Amazingly the proposal passed the usually contentious University Senate without any opposition and with hardly a question. Clearly Martin had done an excellent job paving the way and I had proposed a credible academic program. But toward the end of the same Senate session, some Senators, noting the extraordinarily swift passage of this entire new program, introduced and passed a new resolution which required much more review of any such program in the future. The National Science Foundation saw the use (and need) for such a program in the Washington area and approved a grant to help establish the new department.

7. The First Chair

At first Martin asked me whether I would be willing to be the Chairman of the new program. I declined since (1) I felt that I did not have a sufficient reputation in the community of meteorologists to attract a first class faculty, (2) I was not interested in administration, and (3) I was secure in my own program of research. At Martin's urging I contacted a number of dynamicists whom I knew would fit in well with IFDAM. Some expressed interest but eventually declined. Examples of the latter included Seymour Hess (FSU), Larry Gates (UCLA), and Jack Nordo (Norway).

In the meantime we had attracted the attention of Helmut Landsberg who agreed to give a series of seminars at the Institute to acquaint our faculty with the broad range of meteorological problems and interests. Impressed with Landsberg's experience and noting that he would soon be retiring from government service Martin proposed him as the first Chairman of the Graduate Program in Meteorology. This nomination was passed by the IFDAM faculty and by the Graduate Committee on Meteorology, etc. The Graduate Committee continued to be the governing body of the academic program but, in reality, Landsberg took full control and the Committee agreed with all of his decisions. Among the early academic hires (1967) were Kenneth Gage, David Rodenhuis, Annadu Vernekar, and Owen Thompson (1968). The new faculty members were hired as members of IFDAM, as I had been.

8. Evolution from the Graduate Program

In a series of steps the Graduate Program in Meteorology gradually separated from the Institute in terms of budget, space, self-management, and finally (1978) it was renamed *Department of Meteorology*. I myself remained in the Institute although I continued to teach courses, advise students, and participate in every way in the Department. My first reason was that for a while the Meteorology Program seemed to be on shaky ground. This was due in part to the lack of a large undergraduate-student base. On the other hand external research support per faculty member far exceeded any other department of the University. Nevertheless, about 1972 the University Administration seriously considered moving meteorology to the Eastern Shore campus, which would have resulted in mass resignations and death of the program. Another advantage of me staying in the Institute was that for counting the number of courses taught per faculty member my name could be omitted, but for external publicity it could be included.

Subsequently there have been numerous changes and additions to the faculty, and several major collaborations with NASA and NOAA have been established. In the 2000s the department was renamed *Department of Atmospheric and Oceanic Science* (AOSC). The number of recent extensions and collaborations that have sprung from the original Graduate Program in Meteorology are almost too numerous to mention: JCESS, ESSIC, CICS, AMSC, CHPH, and perhaps others by now. But for more details on these developments one may consult the recently compiled history of the Department of Atmospheric and Oceanic Science.