A PERSONAL VIEW
OF THE HISTORY OF THE DEPARTMENT OF METEOROLOGY
UNIVERSITY OF HAWAII AT MANOA

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This document is a revised version of a presentation I developed for the 50th anniversary of the Department, an event held in Fall 2006. I arrived at UH in 1974 and was a bridge between the early and current epochs in the departmental history. As I near retirement I consider this part of my academic "bucket list".

This is primarily an accounting of the history through the advent of SOEST. The danger of writing about the current era is that some of my colleagues may feel underappreciated in my coverage. Fortunately the time will come when they can write their own versions and updates. I take full responsibility for any opinions stated below.

PRELUDE: Meteorology in Hawaii pre-1956

In December ,1840 the United States Exploring Expedition visited the Island of Hawaii and under the leadership of Lieutenant Charles Wilkes, USN ascended Mauna Loa (Ramage, 1978). This expedition collected some of the first instrumented weather observations in the history of Hawaii. Through the early post contact years individual observers maintained private journals noting all variety of natural phenomena. In 1843 David Malo authored *Hawaiian Antiquities*. He devoted a portion of one chapter to Hawaiian descriptions of weather phenomena. The development of plantation agriculture led to systematic measurements of rainfall and temperature. These records now span more than 120 years. A United States Weather Bureau presence appeared after annexation and routine summaries of "territorial" weather were published. The routine of agricultural observations and Weather Bureau operations continued through the 1930's up to the start of the Second World War.

In the early 20th Century the science of meteorology had developed primarily in Europe and subsequently in the United States. Solid observational and theoretical analyses had led to a reasonably well-defined understanding of synoptic weather systems (the wave cyclone model, polar fronts) , dynamics of planetary wave motions and a theory of formation of precipitation. While some of the few meteorologists residing in the tropics questioned the universality of this body of knowledge the mainstream viewpoint prevailed.

The Second World War forced a number of practitioners of the new field of meteorology to spend years in the tropics . It soon became evident that the principles which had applied to the mid-latitudes were dubious at best in the new theater of activity. In the preface to the his text in Tropical Meteorology, Herbert Riehl (1954) provided an account of his first evening at the newly formed Institute of Tropical Meteorology in Puerto Rico in July 1943. (This was a cooperative institute created by the Universities of Chicago and Puerto Rico.). He stated:

> On the first evening some of staff walked along the beach and admired the beauty of the trade cumuli in the moonlight. Well schooled in the ice-crystal theory of formation of rain, they had no suspicions about these clouds with tops near 8,000 feet where the temperature is higher than +10°C . Suddenly, however the landscape ahead of them began to dim; then it disappeared; a roar approached as from rain hitting roof tops. When some minutes later

they stood on a porch, drenched and shivering, they had realized that cloud tops with temperatures below freezing were not needed for the production of heavy rain from trade-wind cumulus.

There and then the question arose: how is it with the other theories in so far as they concern the tropics?...

Riehl went on to discuss the military needs which justified emphasis on study of tropical meteorology. (Interestingly, this preface text does not appear in his second volume, *Weather and Climate in the Tropics*, 1979).

In the aftermath of the Second World War two significant meteorological research programs developed in Hawaii. One was the Oahu Research Center , a Defense Department (Air Force) funded basic meteorology effort at Wheeler Field. This project was headed by Clarence Palmer then of UCLA who had been founding director of the Institute of Tropical Meteorology in Puerto Rico. This center produced the landmark publication, *The Practical Aspect of Tropical Meteorology*. Palmer also authored the chapter on Tropical Meteorology in the American Meteorological Society's *Compendium of Meteorology* (AMS, 1951). It was never stated formally but much of this work would have been important to the U.S. nuclear testing programs in the Marshall Islands.

Scientists had believed since development of the ice-crystal theory of precipitation in the 1930's that the theory laid the ground work for scientific precipitation augmentation (or as commonly termed ..cloud seeding). During the War Vincent Schaeffer of General Electric Research Laboratories experimented with dry ice and showed that nucleation of ice crystals could occur under the controlled environment of a cloud chamber. This finding plus the development of artificial ice nuclei such as silver iodide encouraged extensive research on weather modification aka rain rainmaking. Agricultural interests in Hawaii became very interested in the possibilities of rainmaking in the islands. Hawaii's climate features substantial inter annual variability of precipitation and the island topography and soils often placed prime agricultural lands in relatively dry regions.

A consortium of the Hawaiian Sugar Planters Association, the Pineapple Research Institute and the Hawaii Cattlemen's Council invested in a major research program predicated on developing weather modification for the Territory. In addition to a highly-talented local staff they funded the University of Chicago to support these studies. Unfortunately this effort immediately encountered the problem that the typical Hawaiian clouds were not amenable to the ice-crystal precipitation process and new research was necessary on the physics of what were termed "warm clouds". Although no meaningful weather modification technique ensued the body of work done included the following significant elements:

1. American Meteorological Society Monograph Vol.1, number 3 , *On the Rainfall of Hawaii, 1951*. This was a superb collection of fundamental research articles.
2. Luna Leopold's seminal work on "Interactions of the trade wind and sea breeze, Hawaii", 1949.
3. Mordy and Eber's paper on "Observations of rainfall from warm clouds", 1954.

4. Project Shower, 1954. A large experiment on the island of Hawaii which brought a number of subsequent stars in the field to the Big Island. A volume of *Tellus* (1957) was devoted to papers based upon Project Shower.

Robert H. Simpson arrived as Chief Meteorologist at the Weather Bureau Office in Honolulu in 1948. In his five-year tenure a number of significant efforts occurred:

1. A Mauna Loa Summit Observatory (1949) was founded. Eventually closed, this facility preceded the 1956 founding of the Mauna Loa Slope Observatory.
2. The naming of the first "official" Hurricane in Hawaii, Hiki in 1950.
3. The first paper on evolution of Kona Storms, identified as subtropical cyclones.
4. The first linking of massive volcanic eruptions to large haze episodes (Mauna Loa, 1950).

As 1956 rolled around the following summarized the state of meteorology in Hawaii:

1. Simpson had moved on to the National Hurricane Research project

2. The Air Force was closing the Oahu Research Center
3. The HSPA/PRI/Hawaii Cattlemen's Council effort had closed down , a consequence of failure to achieve successful weather modification. The individuals moved on; some such as Leopold to other careers; others such as David Johnson to successful careers in meteorology.

As Colin Ramage (personal communication) once told me:

> All the meteorologists in Hawaii (author's comment ..save for those in the Weather Bureau) were out of work.

THE BEGINNING (1956-1964)

(Much of the following material is based on correspondence from Colin Ramage (Ramage, 2006).

On August 19, 1956 the U.S. Air Force signed a contract with the University of Hawaii for " Research directed toward the study of the formation, intensification and movement of typhoons in the Pacific area". Included in the contract were provisions for a training program and donation of a meteorological library. Colin Ramage , then Deputy-Director of the Royal Observatory in Hong Kong, was appointed Associate Meteorologist . In 1958 he became Professor of Meteorology . A Department of Meteorology and Oceanography was established in 1960. The first students graduated with BS in 1960, MS in 1962 and PhD in 1966. In 1964 the University became a member of the University Corporation for Atmospheric Research (UCAR), a consortium of PhD-granting institutions which manage the National Center for Atmospheric Research (NCAR) under a cooperative agreement with the National Science Foundation.

The original staff consisted of Ramage and two Air Force officers (Major James C. Sadler and Captain Forrest R. Miller). The group offered 6-week courses in tropical meteorology to government meteorologists. These offerings later grew to 8-week courses, offered four times per year. In addition to the three above Captains Leighton E. Worthley and Carl J. Wiederanders and Mr. Monte M. Orgill presented lectures and laboratory instruction. The basis for the curriculum was "The Practical Aspect of Tropical Meteorology" by C.E. Palmer (mentioned above) and others (Air Force Surveys in Geophysics, No. 76). Additional materials developed by the Hawaii group were collected in Air Force Surveys in Geophysics No. 126 (1960). These courses formed the basis of the BS program in Meteorology.

The original teaching/research laboratory was in the then-new Chemistry building (Bilger Hall). Almost immediately the program moved to the third floor of the Physical Sciences Building and finally in 1963 moved to the new Hawaii Institute of Geophysics Building (HIG). HIG remains the home of the Department.

Highlights (1956-1964)

1. The IGY El Nino(1957-1958). 1957 was the International Geophysics Year, an international scientific campaign which emphasized Polar (Antarctic) programs. Of interest to our history were two items:

a. The IGY corresponded with a major El Nino event. Of course little was known at the time about El Nino but the IGY timing was fortuitous, coinciding with a worldwide intensive observational campaign. One consequence of the 1957 El Nino was unusual hurricane activity in Hawaiian waters. Sadler recounted attempting to return to Honolulu (with Ramage) after offering a November course in tropical meteorology in the Phillippines (predicated on climatological probabilities of a typhoon landfall) only to be delayed en route due to closure of Honolulu Airport due to Hurricane Nina.

b. The new Mauna Loa Slope Observatory was opened in time for the IGY and Charles Keeling began his famous Carbon Dioxide sampling program (Keeling, 1978).

2. TIROS 1. On April 1, 1960 the Television and Infrared Observational Satellite (TIROS 1) was launched. University of Hawaii meteorologists joined federal scientists on a bluff at Kaena Point, Oahu to interpret the first images at they arrived. Ramage reports that the NASA specialists briefing them:

> focused on getting information from blurred, almost unrecognizable clouds. This pessimism was spectacularly disproved, when superb images poured down, overwhelming the interpreters.

Sadler commented that the major task was navigation, namely figuring out exactly which portion of the planet the image represented.

The Department stored these images as it did those from many subsequent satellites. UH faculty were pioneers in applying satellite imagery to tropical analysis. It became readily apparent that the tropics were much more dynamic and variable than previously thought. In

1964, Sadler published " Tropical cyclones of the Eastern North Pacific as revealed by TIROS observations" in the Journal of Applied Meteorology. In this paper he documented the previously unknown high frequency of East Pacific tropical cyclones as well as presaged the use of satellite imagery in intensity analysis. Subsequent contributions from the UH group included comprehensive atlases of cloudiness and pioneering techniques for satellite-imagery based rainfall estimations.

3. The International Indian Ocean Expedition (IIOE) .

In the aftermath of the IGY oceanographers proposed an international expedition to the Indian Ocean . In 1960, the National Academy of Sciences convened a working group to incorporate meteorology into the expedition. Ramage, a member of the group, was appointed director of the IIOE meteorological program. Support was provided by the National Science Foundation. He and others spent two years in Mumbai (Bombay) at a special International Meteorological Center, operated by the India Meteorological Department. The center plotted and analyzed synoptic charts for the Indian Ocean and surrounding countries and operated the first TIROS read out station and the first meteorological computer (IBM 1620) in India (provided by NSF).

For periods in summer 1963 and the ensuing winter five ESSA and one Woods Hole Oceanographic Institution research aircraft operated out of Bombay. Two ESSA DC-6's flew stacked at 15,000 and 20,000 feet respectively. Among other achievements they made the first penetration of a northern Indian Ocean tropical cyclone, as well as penetrations of mid-tropospheric cyclones over the Bay of Bengal and Arabian Sea.

IIOE data were incorporated into a series of monographs published by the East-West Center Press, as well as two atlases, a textbook on Monsoon Meteorology and many papers and reports . Ramage points out that :

> Notably, IIOE was probably the last big expedition run entirely by participating scientists, assisted by *ONLY ONE COORDINATOR.. Its success spawned imitators, in which managers and administrators outnumbered and often outranked scientists.*

As 1964 wound down the Department had occupied a permanent home, the HIG building, the IIOE field phase was ending, a cloud physics program was developing and the U.S. role in the Viet Nam conflict was expanding.

THE LATE SIXTIES : VIET NAM AND OTHER CONFLICTS

In 1964 a new Department of Geosciences was created with Ramage as chair. As in similar creations the disciplines of Geology, Geophysics, Oceanography and Meteorology were thrust together. Simultaneously the new Hawaii Institute of Geophysics , which housed the research elements of these same fields was growing under its first Director George P. Woollard.

The rivalries which developed among the disciplines and between department and institute were not unique but greatly influenced the evolution of Meteorology at UH.

Highlights (1965-1970)

1. Cloud Physics Observatory

Although the HSPA/PRI cloud seeding venture had been a notable failure, scientists recognized the importance of understanding the microphysics of warm clouds. A strong advocate of such study was Alfred H. Woodcock , who arrived in Hawaii in 1965. The history of Woodcock's arrival is not well documented . Although he has been identified as a member of HIG no proof exists that he ever held an appointment at UH. We can say that he retired from Woods Hole Oceanographic Institute after a distinguished career and settled in Hawaii. He was supported by the Office of Naval Research for many years, seemingly operating out of his private bank account.

In 1965 NSF and the State of Hawaii funded construction of the Cloud Physics Observatory(CPO) on the mauka edge of the UH Hilo campus. Hilo is the rainiest city in the United States (over 3300 mm of annual rain near the coast and more inland) and an ideal location for study of warm cloud precipitation. The opening of CPO coincided with Project Warm Rain (1965) a sequel to Project Shower. As with Project Shower, papers based on this project were published in a special issue of *Tellus.* The founding Director of CPO was E.J. Workman and he was joined by C. M. Fullerton and D. J. Raymond. T. Takahashi eventually joined CPO coincident with Workman's resignation. The CPO facility also provided office space for the NOAA/ Mauna Loa Observatory and the NCAR High Altitude Observatory which maintained a solar observing facility on Mauna Loa.

2. Meteorology and the Viet Nam Conflict

From its inception the UH Meteorology had conducted research in support of improving tropical weather forecasting and a primary supporter had been the U.S. military. This did not change during the Viet Nam conflict. Sadler led a program which conducted fundamental research on meteorology of Southeast Asia, provided training forecasters and even included visits to the field (namely Viet Nam) by UH staff. I have talked to meteorologists who had been stationed in Viet Nam and been the subject of review by Sadler and colleagues. Studies from this time are featured in the Forecasters Guide to Tropical Meteorology, Air Weather Services Technical Report 240 (1995, revision by C.S. Ramage).

Like many U.S. campuses of the time, UH was embroiled in the turmoil of the period. I once asked Sadler about those times. He recounted that his standard comment was that improved weather forecasts saved lives on both sides of the conflict. The UH ROTC building was burned but the HIG seemingly was left alone.

3. The Line Islands Experiment

This experiment coincided with the launch of the Applications Technology Satellite (ATS) 1 in 1967. This was the first geostationary platform available for meteorological applications. ATS 3, a later platform which covered the Atlantic and continental U.S., is more well known. Geostationary platforms allow continuous tracking of evolving weather systems which had been determined to be major elements of tropical weather. Zipser's first model of tropical squall lines (mesoscale convective systems) is based upon Line Islands observations.

As mentioned previously the marriages of the multiple disciplines with both the Department of Geosciences and the Hawaii Institute of Geophysics were failing by the late-sixties. By 1970 the meteorologists had petitioned to be separated from both the Department of Geosciences and the Institute. Their petition was granted. However, in the great tradition of the University, implementation took time. (When Schroeder arrived in 1974 his personnel actions still required signature by the Director of HIG.) The Cloud Physics Observatory joined the meteorology exodus from HIG.

In 1972 the State of Hawaii encountered fiscal hard times. The Viet Nam protests and related problems tarnished the University's reputation in the view of many of the Hawaii public. A long period of post-statehood expansion halted and the University suffered serious budgetary problems. Faculty collective bargaining had a rocky start as well. The faculty went four years without a collective bargaining agreement and consequently no salary adjustments.

INDEPENDENCE (GOOD AND BAD) 1970-1987

The Department now consisted of 10 faculty , 7 at the Manoa campus and 3 at the Hilo facility. The Department's strength in tropical meteorology was widely recognized. UH scientists were key participants in the major atmospheric experiments of the time. Scientists from around the globe visited the Cloud Physics Observatory and the facility supported a number of special field expeditions. New opportunities arose as NOAA launched operational geostationary satellites to cover the Pacific, the 1973 Energy crisis led to serious considerations of alternative energy sources for Hawaii, seasonal to inter annual climate variability became a topic of broad societal concern and the US National Weather Service approached a massive modernization.

Manoa staffing remained stable throughout the period. CPO lost one position when David Raymond resigned, leaving a staff of 2. In 1978, the Department was singled out for a low student/faculty ratio and persisted as a target for legislative and campus-level scrutiny through the 1980's. Looming on the horizon were an anticipated retirement wave. CPO also proved an expensive prospect for an academic department to maintain. The legislature began to pressure the University to reallocate resources in lieu of perennially requesting more and more. I arrived in 1974 and much of the subsequent discussion is from my perspective.

Highlights

1. GARP/GATE and MONEX

The Global Atmospheric Research Program (GARP) Atlantic Tropical Experiment (GATE) was an ambitious international venture targeting the tropics. The selection of a location for a tropical experiment was subject to high-level international diplomacy. The outcome was a move from an original proposed Pacific experiment to one based on the Atlantic. Concerns over the global application of an Atlantic experiment led Ramage to withdraw from the planning committee. (Ironically his vision was realized when nearly two decades later the Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) was conducted in the tropical Pacific.) Sadler, nevertheless, participated in the field phases and produced a superb synoptic atlas of the entire GATE period.

At the end of the 1970's GARP conducted the First GARP Global Experiment (FGGE). A major element was a Monsoon Experiment (MONEX). There were two field phases , Winter and Summer. Ramage, Sadler and Takio Murakami were prominent figures in MONEX. Ramage , Sadler and associates (including a young doctoral student named Steve Lyons) participated in the Winter MONEX field phase, based in Kuala Lumpur. Murakami participated in international planning committees as well as conducted years of productive research with the data. His exceptional career culminated in his receipt of the Meteorological Society of Japan's highest award , the Fujiwahra Award.

2. El Nino Studies and related programs

The 1957-1958 IGY El Nino brought the phenomenon to the attention of the global meteorological and oceanographic communities. The 1972-1973 El Nino coincided with the collapse of the Peruvian anchoveta fishery and an associated economic catastrophe. Ramage led a study of the meteorology of that event. UH scientists were leaders in national panels steering El Nino studies. The 1972 event occurred in the midst of a decade- long North Pacific Experiment (NORPAX) which was predicated on climate analysis with an eye to prediction. Sadler was an active participant in NORPAX. Equatorial Pacific Ocean Climate Studies (EPOCS) was NOAA"s research effort in seasonal-to-interannual climate prediction, the new term encompassing El Nino studies. UH meteorologists and oceanographers were leaders in EPOCS. The name EPOCS persists within NOAA lexicon, serving as the account which provides base funds to the Joint Institute for Marine and Atmospheric Research (JIMAR). In 1985 the Tropical-Ocean Global Atmosphere (TOGA) became the international program to develop seasonal-to-interannual climate prediction. El Nino and the Southern Oscillation (by then termed ENSO) remained the primary focus. UH competed for two TOGA data/analysis centers , a sea level center proposed by Klaus Wyrtki of Oceanography and a wind center proposed by Sadler. The sea level center was supported but the wind center was awarded to Florida State University.

The UH reputation for excellence in monsoon and El Nino research was an important factor in the 1990's development of an International Pacific Research Center (IPRC, discussed later).

3. GOES (Geostationary Operational Environmental Satellite)

The development of the SMS/GOES satellite series had profound impacts on operational and research meteorology in the Hawaiian Islands. The Line Islands Experiment and GATE had demonstrated the value of geostationary platforms in routine monitoring of evolving tropical weather systems. UH Meteorology became an archival site for the products prepared by the Satellite Field Services Station, Honolulu. These comprised hard copies of all images as well as negatives of the Full-Disc images. (Years later the negatives proved a useful source of funds due to recycling of then-pricey silver- based negatives.). We also stored 16-mm movie loops. Students and faculty made extensive use of these products. The impact of these products on daily forecasting in Hawaii was profound but it soon became evident that satellite imagery was not necessarily the panacea anticipated. It had been hoped that weather systems would be easily tracked and forecast through simple persistence. It became evident that they also evolved. Standard mid-latitude satellite cloud analyses failed when applied to efficiently precipitating warm clouds. (Two decades later weather radar became available in Hawaii.)

4. Alternate Energy Studies

The 1973 Oil Embargo sent a shock through the Hawaii economy as well as nationally. By 1975 the Department had taken the lead in assessing the wind energy resource for the State replacing some initial efforts by local engineers. We recognized that the trade winds must of necessity be the source of any useful wind power production and focused on behavior of the trades interacting with island topography, an intriguing basic science subject in its own right (Ramage, 1979) . A series of small State-supported projects demonstrated viable resources . The approach was to survey favorable areas of each island using portable meteorological stations (constructed in surplus military vans) to sample local winds during standard trade wind conditions , establishing long-term monitoring sites and correlating observations at these sites with long-term records from first-order weather stations (Daniels and Schroeder, 1978).

In 1977 the Department successfully competed for a five-year grant establishing a Solar Energy Meteorological Research and Training Site, part of a Department of Energy(DOE) network of such sites. We expanded exploration of direct solar and indirect (wind) energy sources in the state. Emphasis was on the properties of the resources. In the case of wind, these included terrain amplification, steadiness, variations in the vertical and turbulence. Anders Daniels recognized the value of tethered kites as wind sensors , refining the measurements and quantifying detailed wind characteristics especially turbulence. By 1981 the wind resources were well documented. A series of DOE prototype wind turbines were installed in Kahuku, Oahu, as was an early commercial wind farm. An initial Mod-0A turbine was the most successful in DOE's national test national test program. Other early generation turbines failed as did those on a pair of commercial wind farms on Hawaii Island. The Hawaiian environment was

a rigorous test of the systems and the technology wasn't ready. By 1990 (with the exception of a small farm with small generators operated by the Island of Hawaii Board of Water Supply) wind energy development had come to a halt statewide. Ironically as I write this account (July 2006) a modern wind farm has gone on line on the island of Maui with more in the offing. The methodology we developed for island wind prospecting was published as a WMO Tech Memo (Daniels and Schroeder,199 -).

5. The advent of JIMAR (1977)

In 1967 the University of Hawaii and the Environmental Sciences Services Administration (ESSA) had created a Joint Tsunami Research Effort (JTRE). This was a consequence of mutual interest arising from Hawaii's long history of tsunami tragedy and the recent Alaskan (1964) disaster. By 1977 JTRE's future was in doubt owing in part to lack of recent tsunamis and the untimely death of director Gaylord Miller. Fortunately this crisis coincided with a NOAA (successor to ESSA) initiative to create more cooperative institutes based on the successful Cooperative Institute for Research in the Environmental Sciences at the University of Colorado in Boulder. A Memorandum of Understanding was signed by the University and NOAA on September 29, 1977 creating a Joint Institute for Marine and Atmospheric Research (JIMAR). Its mission is to facilitate cooperative research on matters of mutual interest to the two parties. The research agenda initially incorporated three themes, two of which (Equatorial Oceanography and Climate) were directly linked to our ongoing El Nino research. In 1995 a tropical meteorology theme was added. Early Senior Fellows included Ramage, Sadler and Murakami. The founding Director was Dennis Moore , an oceanographer. In 1996 Schroeder succeeded Moore as Acting Director and became permanent Director in 1998. JIMAR has served as a conduit for NOAA funds and a source of support for post-doctoral researchers.

6. A proliferation of postdocs

The expansion of research programs in the late-1970's in a diverse range of subjects stretched the Department resources. We became convinced that post doctoral researchers would be a wise investment. JIMAR , through its Visiting Scientist Program, served as a source of more than a half-dozen postdocs between 1977 and 1985. Additional postdocs were supported by the DOE Solar Energy site. These young scientists provided an intellectual boost to our programs, making significant scientific contributions and for the most part have moved into successful careers in a variety of venues.

7. China

When U.S.- China relations warmed in the 1970's, the University of Hawaii, which prides itself on its Asia-Pacific emphases, expected an influx of Chinese scholars and students. The Department's reputation in China (which has 30,000 meteorologists) was strong, dating back to Ramage's days at the then-Royal Observatory, Hong Kong. By the late-1970's several Chinese

scientists had visited the Department , primarily collaborating with Ramage and Murakami. The University Administration was surprised when the first Chinese-funded graduate student to attend UH enrolled in the Department of Meteorology.

The opening of China has profoundly impacted the evolution of our program. Foreign students have always comprised a significant portion of our student population. The Chinese students who have attended UH in recent decades have enriched the Department. Five of our current faculty originate from China as well. Now our faculty routinely visit China, attend international meetings there and serve in honorary positions with Chinese institutions.

8. Polynesian Voyaging

Soon after my arrival Ramage lent me a copy of *We The Navigators*, by David Lewis. He also pointed to research (Levison et al, 1973) which demonstrated that the outliers of the Polynesian triangle (Hawaii, Rapa Nui (Easter Island) and Aotearoa (New Zealand) could not have been discovered by accidental drift voyaging but must have been found through exploratory voyages. He told me about an effort to build a Polynesian voyaging canoe and stage a non-instrument voyage to Tahiti and back. The boat was *Hokulea* . Ben Finney , a UH anthropologist was one of the leaders of the effort. Ramage and Sadler provided their exceptional tropical weather experience to the preparation for what became a successful 1976 voyage , summarized by Finney in *Hokulea, The Way to Tahiti* (1979).

A Polynesian Voyaging Society staged a number of subsequent expeditions involving not only the *Hokulea* but also locally built *Makalii* and *Hawaiiloa* as well as several canoes from other Polynesian nations. The Department continuously supported these voyages both in voyage planning , offering special training sessions to new navigators, and, in later years, direct communication with navigators at sea. Communication with navigators at sea were under strict protocols (no discussion of true position) and predicated on safety. The last directly supported voyage was from French Polynesia to Rapa Nui (Easter Island). *Voyage of Rediscovery* (Finney et al, 1994) provides a history of the rediscovery of Polynesian navigation as well as describes a multi-year voyage throughout the Polynesian triangle (save Rapa Nui) by *Hokulea* .

RETIREMENTS, POSSIBLE CLOSURE, AND THE ADVENT OF SOEST (1987-1989)

(Opinions expressed here are solely those of the author.)

As the 1980's drew to a close the department was under substantial pressure from the UH administration due to the student-faculty ratio discussed previously. These same administrators were under pressure from the Governor and Legislature to offer up internal re-allocations of resources as the price for new funding (see David Yount's *Who Runs the University*, 1996). They also recognized that a large wave of retirements were pending.

The Department had already down-sized the Cloud Physics Observatory. CPO had become an expensive operation . The electric bill consumed nearly the entire operating budget of the department. Proposed faculty exchanges between CPO and Manoa (one of the conditions of Schroeder's hire) never materialized. The CPO faculty operated in isolation. The Hilo campus had managed to annex much of the CPO facility, even evicting our Mauna Loa Observatory and NCAR colleagues. This was remarkable since they did not own the facility . In 1983 Fullerton moved to the UH Hilo campus as Dean of Arts and Sciences. Manoa proposed closing CPO and transferring the remaining faculty member and one technician to Manoa.

Timing couldn't have been worse. The Hilo economy had been in gradual decline. The CPO announcement coincided with closure of a Job Corps facility and other bad news. The Hawaii County Council got involved. After the ensuing political maelstrom, the outcome was transfer of the vacant (Fullerton) position to Manoa , eventual transfer of the technician position as well and a residual one-person operation at CPO. This situation persisted until 1989.

Meanwhile the retirements began . A total of five retirements occurred between January 1987 and July 1989. In anticipation of these retirements the Dean of Natural Sciences proposed drastic action. He wished to terminate three probationary faculty and reassign the two remaining tenured faculty, thereby closing the department.

In 1985 the University Marine Council had begun planning a new School of Ocean and Earth Science and Technology (SOEST). The new school would incorporate the departments of Geology and Geophysics, Ocean Engineering and Oceanography as well as three Organized Research Units (HIG , the Hawaii Natural Energy Institute (HNEI) and the Hawaii Institute of Marine Biology (HIMB)) plus Hawaii Sea Grant among others. Ramage had brought Meteorology into the discussions and Meteorology was incorporated in the prospectus for SOEST.

The College of Natural Sciences was not pleased. Three units would be departing . HIMB faculty also held appointments in the College (primarily in Zoology). Geology and Geophysics and Oceanography were two recognized stars of the campus and their departure would take much prestige with them. And, of course, resources would be leaving, especially the potential remains of the Department of Meteorology.

The SOEST proposal gradually worked its way through the University process. In anticipation of its approval a "shadow government" formed with Charles Helsley, Director of HIG, as "interim Dean" and Lorenz Magaard , Chair of Oceanography and principal author of the SOEST proposal, as "Associate Dean".

Colin Ramage retired on January 1, 1988. Colin had directed the program from its onset and his presence was to be sorely missed. Schroeder assumed the role of Acting Chairman of Meteorology with the primary mission of finding a real chairperson. An example of the stresses of the time was that an advertisement had been placed for a new professor and chair with the approval of the "shadow government" and to the dismay of the College of Natural Sciences.

Schroeder's first day as new Chair actually was Monday January 4, 1988. In rapid order four things struck that morning:

1. The Committee on Natural Disasters, National Research Council called enquiring as to the appropriateness of organizing a survey team in response to the Oahu flooding of New Years Eve. (Dracup et al, 1991).

2. The University informed him that the 5-year program review of the Department was due that year. A self-study was due that spring.

3. UCAR informed him that the University's membership renewal materials were due that spring.

4. The College of Natural Sciences delivered papers documenting the vacancy created by Ramage's retirement.

Remarkably within a matter of mere weeks a professorship in Meteorology became a technical support position in Physics. This action set the tone for two years of struggles. Battles centered on recovery of the Ramage position (note: positions, especially position numbers, are "gold" in the UH system.) which never happened, recruitment of a new Chairperson and a debate over the concept of relocating the Honolulu Weather Forecast Office to the Manoa campus (separate section later). Heroes in the struggles were the "interim SOEST administration (SOEST was approved by the UH Board of Regents in July 1988) and the Vice-President for Research and Graduate Education. We were able to prevent loss of any more positions, use temporary faculty (drawn from resident soft-money researchers) , increase graduate student enrollments and preserve (even expand) the research portfolio.

The tide turned in 1989 with the hires of C.B. Raleigh as Dean of SOEST and D.E. Stevens as Professor and Chairman of Meteorology. Raleigh came from the directorship of Lamont Doherty Earth Observatory (then "Geological Observatory") where he had overseen the develop of early El Nino forecasts and had an appreciation of the climate side of atmospheric sciences. The young and energetic Stevens came from the Department of Atmospheric Sciences at Colorado State University. Colorado State was considered with Hawaii and Florida State as one of the top three tropical meteorology programs. These two rapidly began the rebuilding of the department. Raleigh had identified climate research as one of three main thrusts in his prospectus for SOEST and was able to obtain new positions for climate research. Thus we were able to fill the existing vacancies plus additional new ones. Between 1991 and 1993 Gary Barnes, Steven Lyons, Fei-Fei Jin and Steven Businger (upon Lyons' departure) joined the Department. SOEST embraced new opportunities. The NWS move occurred and an the International Pacific Research Center (IPRC) was created. As part of the University commitment to IPRC , Kevin Hamilton, Tim Li, Shang-Ping Xie and Yuqing Wang were recruited. As of July 2006 the Department has 13 tenure-track faculty, three dozen graduate students (approx) and a

small but vigorous undergraduate program. This constitutes a near doubling of faculty and tripling of graduate student population since 1988.

THE SOEST ERA (1989 to present)

1. Hawaiian Rain Band Project (HaRP) , Taiwan Mesoscale Experiment (TAMEX) and subsequent local weather studies.

In 1985 scientists returned to Hilo for another warm rain project (the Joint Hawaiian Warm Rain Project). The impetus arose from procurement of new aircraft at NCAR as well as the detailed studies of the Hilo warm clouds by Tsutomu Takahashi of CPO. In preparation for this project NCAR scientists conducted some original numerical experiments with a sophisticated mesoscale model. The results offered a contrast to the locally long-accepted view of the physics governing the circulations on windward Hawaii. Many of us had recognized the value of the Big Island as a laboratory in which reproducible (at least by meteorological standards) experiments could be conducted.

A large experiment (HaRP) was conducted in summer 1990 to test the modeling results. This project brought scientists from a range of institutions and nations together on Hawaii . With these scientists came an impressive array of aircraft , remote sensing equipment , portable surface weather stations and even seaborne observations. 100 rain bands formed east of Hilo in 42 days. The HaRP data sets have served as basis for dozens of scientific papers, numerous dissertations and theses and student term projects.

Also in the mid-1980's meteorologists in Taiwan and the United States planned and conducted a mesoscale weather experiment (TAMEX) on the island of Taiwan and its surrounding waters. TAMEX was a study of the pre-monsoon Mei-yu of southern China and Taiwan. Yi-Leng Chen and a cadre of students explored cases during the 1987 field phase . The scope of studies ranged from the nature of the "Mei-yu" front (not necessarily barotropic as historically hypothesized), barrier jets along the western shore of Taiwan, and sea-breeze circulations. The National Science Foundation supported TAMEX study for well over a decade. Both Chen and Pao-Shin Chu maintain strong ties with meteorologists in Taiwan.

Beginning with the HaRP analysis faculty began a continuing series of projects utilizing more-and-more sophisticated regional numerical models. Topics have included among others:

1. Island circulation features (Chen)
2. Daily weather forecasts including fire weather (Chen, Stevens)
3. Support of astronomy on Mauna Kea and Haleakala (Businger)
4. Dispersion of Volcanic Smog (VOG) from Kilauea volcano (Businger)

2. Tropical cyclone studies

Tropical cyclone research (the source of the original contract in 1956) had gone dormant in the 1980's. In the late 1980's the Office of Naval Research developed an accelerated research initiative in Tropical Cyclone Motion. UH and especially a dynamic new faculty member, Bin Wang, became significant contributors to basic studies of tropical cyclone motion and key participants in the 1990 Tropical Cyclone Motion field experiment in Guam. Ramage came out of retirement to participate. ONR-sponsored tropical cyclone studies continue, extending to genesis and intensity.

Gary Barnes joined the faculty in 1991 adding an exceptional observational skills to the program. He has strengthened our collaborations with the Hurricane Research Division (HRD) in Miami. Two HRD scientists are JIMAR Fellows and two are affiliate graduate faculty. A number of students have published MS thesis based on plentiful yet underutilized HRD data sets. Several of our students have gained aircraft experience as well. Barnes is supported by the U.S. Weather Research Program (NSF).

Hawaii meteorologists have also offered a novel approach to hurricane observation. Steven Businger and colleagues have proposed and tested smart tetroons as hurricane probes. Preliminary experiments have been conducted.

(Additional contributors to tropical cyclone research are Tim Li and Yuqing Wang, mentioned later under the International Pacific Research Center)

3. Hurricane Iniki and Hawaii hurricane issues

On September 11, 1992 Hurricane Iniki made landfall on Kauai as a Category 3 storm constituting the greatest natural disaster in the history of the State. Schroeder provided live commentary on the local NBC affiliate. This provided the Department and UH with a positive public image. In the aftermath of Iniki UH faculty have been in high demand as participants on state advisory panels (civil defense and hurricane insurance funds), as consultants to state and private industry and as public resources. Iniki also provoked a change in attitude of the broadcast media towards on-the-air weather content. Prior to Iniki there was little TV weather coverage; one station had a dedicated weather person. Subsequently several UH students have gained broadcast experience and UH faculty have assisted novice weathercasters .

4. National Weather Service modernization and Honolulu relocation

In 1986 Ramage attended a retreat at Estes Park , Colorado the topic of which was the planned modernization of the National Weather Service. Among the aspects of the modernization was an initiative to move forecast offices to university campuses where feasible. Such arrangements had existed in the 1950's and 1960's in Chicago and Miami. Honolulu was identified as one of 8 “candidate” sites. Ramage and Richard Hagemeyer, Pacific Region Director, began to explore the possibilities. Subsequent to Ramage’s retirement discussions

continued between the shadow SOEST administration, the UH President's office and the NWS . A new building (the Pacific Ocean Science and Technology building) was in the planning phases and thus some space within the nascent school could be available for a NWS facility.

Raleigh and Stevens reinvigorated these discussions and through great persistence orchestrated an agreement between the University and the NWS in 1992. NWS would be assigned space in the HIG Building (second floor) which they would renovate. In lieu of rent an annual grant would be made to JIMAR creating a National Weather Service Fellowship fund. JIMAR added a new research theme in Tropical Meteorology. This fund was seeded by NWS prior to the actual moves occurred. This fund would support graduate students in SOEST.

In the great tradition of UH the POST building fell behind schedule while the NWS move had to occur on schedule. This created a space crisis. In a remarkable display of collegiality faculty got together with the SOEST administration and worked out a short-term space compression which pleased no one but facilitated the NWS renovations.

In July 1995 the Honolulu Weather Forecast Office (WFO) on the Manoa campus was dedicated. The Department and WFO were in the closest physical proximity of any such arrangement in the nation. Only recently Tallahassee (Florida State University) and Norman. Oklahoma (under construction) have (or will attain) similar proximity.

The arrangement has been a success. UH students have worked within the WFO, NWS Fellows (graduate students supported by in-lieu-of-rent funds) have completed MS Thesis on applied forecasting topics. A number of these students have pursued careers in the NWS, some even returning to Honolulu. Faculty have joined NWS staff in special research efforts funded by the Cooperative Meteorological Education and Training (COMET) program.

NWS staff attend departmental seminars. A local American Meteorological Society chapter (dormant since the mid-1980's) has been revived. Faculty, students and forecasters have had stimulating discussions of forecast issues at regular weather briefings. NWS/NOAA outreach has benefitted from access to the 3000 students visiting the biennial SOEST open house.

5. The International Pacific Research Center (IPRC)

In 1996 representatives of UH , US Federal agencies and colleagues from similar institutions in Japan negotiated the establishment of a US-Japan research center in Hawaii at the UH. Part of Japan's Frontier Research Program in Global Change and an element of the US-Japan Common Agenda, the center would focus on climate of the Asia-Pacific region. UH was selected because of its eminence in oceanography and meteorology and its long history of Asia-Pacific emphasis. UH committed 10 tenure-track faculty positions to this enterprise, 9 of which have been filled. Five of these are members of the Meteorology faculty. These faculty have provided breadth to the program, served in many international (Asia) venues, generated independent funding support and supported additional graduate students. .

IPRC scientists specialize in modeling and diagnostic studies of climate variability and global change. The IPRC has provided a natural home for Bin Wang's studies of monsoon dynamics and tropical climate variability, and he was a founding member of IPRC.

The advent of IPRC also allowed for the hiring during 1999-2004 of four outstanding young or mid-career meteorology faculty.

Tim Li who received his PhD from the department in 1993 was the second alumnus to be hired as a faculty member (after Lyons, 1991) when he joined the faculty in 1999. Li has excelled in studies of coupled ocean-atmosphere dynamics in the tropics as well as in research related to tropical cyclogenesis and forecasting.

Shang-Ping Xie, also hired in 1999 is performing innovative model and observational diagnostic studies of air-sea coupling phenomena. His work is particularly notable for pioneering applications of high-resolution satellite data in studies of tropical ocean-atmosphere interaction at mesoscales.

Yuqing Wang had been a researcher at the IPRC and afiliated graduate faculty in the department for several years when he joined the regular faculty at the beginning of 2004. Wang has developed his own atmospheric dynamical model that has versions adapted for tropical cyclone simulation and for regional climate simulations and has also been extended to a regional coupled atmosphere-ocean model. Wang has applied his model to numerous aspects of tropical weather and climate with a focus on the crucial issue of the simulation of clouds and precipitation.

A key aspect of the IPRC mission is modeling of global change with a focus on effects on the Asia-Pacific region. Prof. Kevin Hamilton was hired from NOAA's Geophysical Fluid Dynamics Laboratory where for many years he led the stratospheric modeling effort. At IPRC Hamilton has extended his interests to tropospheric climate modeling and he leads the global change research group. In 2004 he became Department Chair.

6. The Hawaii State Climate Office

In 1973 NOAA"s State and Regional Climatology offices were closed. Historically these offices resided on the campus of the State's Land-Grant university. The various states reacted differently. Some continued the programs with state funds at the University. These offices were expected to be entrepreneurial. Although a series of UH Meteorology chairs had attempted to secure a state climatology office for the Department Hawaii chose to maintain a low-key records office within the Department of Land and Natural Resources (DLNR). An ad hoc triangle of DLNR, the Pacific Region Office and UH Meteorology provided climate services as best they could.

Finally in 2000 DLNR contacted the Department offering to turn over all records and responsibilities. The Chair and Dean Raleigh agreed to take on the program, providing support for students to support a faculty member , Pao-Shin Chu, who volunteered to become the State Climatologist. This arrangement has worked. The Hawaii State Climate Office provides essential services and is an excellent bridge to the Hawaii public. Ironically NOAA has come full circle as a program in Climate Observations and Services has grown anew.

7. The Pacific ENSO Applications Center

Presaging the redevelopment of NOAA climate observations and services, the Department partnered with JIMAR, the University of Guam, the National Weather Service Pacific Region, the UH Social Science Research Institute and the Pacific Basin Development Council to establish the Pacific ENSO Applications Center (PEAC) in 1994. The East-West Center later became a prominent partner as well. The concept of a PEAC arose out of expressed needs of the leaders of US-Affiliated Pacific jurisdictions for clear-cut usable climate outlooks. PEAC is staffed by a research scientist and a NOAA Commissioned Corps officer. They produce quarterly climate summaries and outlooks, support a web page, conduct outreach and develop new products.

PEAC rose to prominence during the 1997-1998 El Nino. PEAC transmitted the outlooks, (even presaging some of the official NOAA statements) issued special advisories, traveled throughout the islands presenting public sessions on El Nino impacts and worked with Federal response agencies. UH faculty attended public forums on the forthcoming El Nino for local (Hawaii) audiences.

A special forum on PEAC review was held at the East-West Center in 2004, marking 10 years of PEAC. An international audience evaluated PEAC , offering advice on future directions. PEAC is a prime example of a University partnering with other agencies to develop a proof-of-concept. PEAC is now in transition as the National Weather Service slowly absorbs it as part of their operations.

8. The Mauna Kea Weather Center

In 1993 Steven Businger joined the Department. Among his wide range of interests was application of Global Positioning System (GPS) technology to atmospheric remote sensing, specifically use of the wet-delay of the GPS signal to infer precipitable water. Schroeder realized that such technology would be of great interest to the UH Institute for Astronomy (IFA) and suggested a meeting between Businger and the IFA Director. (Atmospheric water is a bane to astronomers, especially those using Infra Red telescopes such as on Mauna Kea).

The discussions shifted to a different and , in the long-term, very rewarding topic, meteorological support of Mauna Kea operations. The product of this discussion is the Mauna Kea Weather Center. This center, supported by the various telescope operators, provides detailed

daily weather forecasts as well as experimental forecasts of "seeing" and turbulence. This is a wonderful example of interdisciplinary cooperation achievable in Hawaii. The Mauna Kea Weather Center has been featured in the Bulletin of the American Meteorological Society (Businger et al, 2001).

INTEGRATION OF INSTRUCTION AND RESEARCH (The Academic Program through the years)

The research and instruction elements of UH meteorology developed in tandem. The academic program has been noted for its rigor throughout its history. Students at all degree levels have had opportunity to participate in the research projects within the department. In the beginning a young BS candidate worked with Mariano Estoque in what has been recognized as classical numerical modeling of the sea breeze. The computational skills he obtained led him to a long career as director of the University's computing center. Many undergraduates have pursued careers in the civilian and military weather services; others have pursued advanced degrees. A notable alumnus is Steven Lyons who earned all three degrees from UH Meteorology. His career has led him to a variety of interesting positions in private sector, university and government. As hurricane specialist for the Weather Channel he arguably has been the University's most recognizable alumnus. While an undergraduate he helped develop the first classroom forecasting contest in the department. As a graduate student he spent a summer as an intern with the Satellite Field Services Station at the Honolulu NWS Office and also participated in the Winter MONEX field program in Kuala Lumpur, Malaysia. These are examples of the opportunities we present our students. The on-campus Weather Service Forecast Office provides plentiful exposure to modern operational meteorology and some employment opportunities. At times graduate students have served internships at the Joint Typhoon Warning Center , Pearl Harbor.

The instructional program is also noted for its flexibility. Undergraduates and graduates enroll in elective courses with sister departments, such as Geography and Oceanography. Historically our students took classes in agricultural meteorology taught through the College of Tropical Agriculture and Human Resources. Undergraduate majors have at times studied history of science and hydrology as well.

The Department has also provided significant service courses to the broader university community as well. MET 101 has been offered at Manoa and Hilo (by Fullerton) and we have supported offerings within the Community College system. Faculty also offer special lectures in other departments. For 19 years Schroeder contributed to the Natural History of the Hawaiian Islands (co-taught by the Departments of Botany and Zoology/ BOT/ZOO 450).

The program has always featured an international (Asia and Pacific) emphasis. Our students have always reflected this emphasis as well. Among the nations and U.S. affiliated territories represented in our alumni are:

Japan, Taiwan, Peoples Republic of China, South Korea, Viet Nam, Thailand, India, Nepal, Sri Lanka, Indonesia, Fiji, England, American Samoa, Belau, Pohnpei, Chuuk, the Marshall Islands, Guam.

One of the highlights of the modern era in the department has been the growth of the graduate program. In 1988 the total graduate student population was about 12 ; we now average about 36 students about evenly divided between the Masters and PhD. The growth resulted from a concerted effort to support students through our research grants as well as special opportunities afforded by the National Weather Service Office on the Manoa campus.

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