Cloud Systems, Hurricanes, and the Tropical Rainfall Measuring Mission (TRMM)

A Tribute to Dr. Joanne Simpson

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# TABLE OF CONTENTS

**Preface** ............................................. v  
**List of Contributors** .................................. vi

## Part I. Joanne Simpson’s Career

### Chapter 1
The Research of Dr. Joanne Simpson: Fifty Years Investigating Hurricanes, Tropical Clouds, and Cloud Systems  

### Chapter 2.
Joanne Simpson: An Ideal Model of Mentorship  
—ROGER A. PIELKE SR.  .......................... 17

## Part II. Cloud Systems—Observations

### Chapter 3.
What We Have Learned about Field Programs  
—MARGARET A. LEMONE  ............. 25

### Chapter 4.
From Hot Towers to TRMM: Joanne Simpson and Advances in Tropical Convection Research  
—ROBERT A. HOUZE JR.  .......................... 37

### Chapter 5.
Some Views on “Hot Towers” after 50 Years of Tropical Field Programs and Two Years of TRMM Data  
—EDWARD J. ZIPSER  ............................... 49

### Chapter 6.
Spaceborne Inferences of Cloud Microstructure and Precipitation Processes: Synthesis, Insights, and Implications  
—DANIEL ROSENFELD AND WILLIAM L. WOODLEY  .......................... 59

### Chapter 7.
Isotopic Variations and Internal Storm Dynamics in the Amazon Basin  
—ISABELLA ANGELINI, MICHAEL GARSTANG, STEPHEN MACKO, ROBERT SWAP, DEREK STEWART, AND HILLÂNDIA B. CUNHA  .......................... 81

## Part III. Cloud Systems—Modeling

### Chapter 8.
Cloud Models: Their Evolution and Future Challenges  
—WILLIAM R. COTTON  .......................... 95

### Chapter 9.
Goddard Cumulus Ensemble (GCE) Model: Application for Understanding Precipitation Processes  
—WEI-KUO TAO  .......................... 95

## Part IV. Hurricanes

### Chapter 10.
Hot Towers and Hurricanes: Early Observations, Theories, and Models  
—RICHARD A. ANTHES  .......................... 111

### Chapter 11.
On the Transverse Circulation of the Hurricane  
—WILLIAM M. GRAY  .......................... 111

### Chapter 12.
Some Aspects of Midlevel Vortex Interaction in Tropical Cyclogenesis  
—ELIZABETH A. RITCHIE  .......................... 165
## Part V. TRMM—History and Management

**Chapter 13.** My View of the Early History of TRMM and Dr. Joanne Simpson’s Key Role in Winning Mission Approval  
—JOHN S. THEON ........................................ 175

**Chapter 14.** Dr. Joanne Simpson and the Beginning of the TRMM Project  
—TOM KEATING .......................................... 181

**Chapter 15.** Working with Dr. Joanne Simpson while Managing the TRMM Project  
—THOMAS LA VIGNA ..................................... 183

## Part VI. TRMM—Science Aspects

**Chapter 16.** A Short History of the TRMM Precipitation Radar  
—KEN’Ichi OKAMOTO ............................... 187

**Chapter 17.** The TRMM Measurement Concept  
—THOMAS WILHEIT ..................................... 197

**Chapter 18.** GATE and TRMM  
—GERALD R. NORTH ................................. 201

**Chapter 19.** Performance Evaluation of Level-2 TRMM Rain Profile Algorithms by Intercomparison and Hypothesis Testing  
—ERIC A. SMITH AND THROY D. HOLLIS ............. 207

**Chapter 20.** Status of TRMM Monthly Estimates of Tropical Precipitation  
—ROBERT E. ADLER, CHRISTIAN KUMMEROW, DAVID BOLVIN, SCOTT CURTIS, AND CHRIS KIDD ............. 223
Chapter 2

Joanne Simpson: An Ideal Model of Mentorship

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ABSTRACT

The role of cumulus clouds in local, regional, and global weather and climate that is understood today is based to a large extent on the pioneering work of Joanne Simpson. Her involvement in this work is illustrated through the experiences as my career developed. She also was, and is, an ideal model of mentorship. This paper illustrates this model using my interactions during the 1970s and early 1980s, and how they have influenced research articles up to the present.

1. Experimental Meteorology Lab Years

In 1971, Dr. Simpson was director of the Experimental Meteorology Laboratory (EML) when I joined as a graduate student. Her original papers (Stern and Malkus 1953, Malkus and Stern 1953) provided a framework to develop a sea-breeze numerical model and to apply this tool to better understand mesoscale and cumulus dynamics in south Florida. Figure 1 from her work demonstrates the concept of the “equivalent mountain,” which results from surface heating of land (Fig. 2.1). Air is lifted, as a result, as it passes over the land. This provided an original explanation of why cumulus clouds preferentially develop over and downward of tropical islands even in the absence of topographical relief. Figure 2.2 illustrates this preference for rain showers downwind of such islands (in this case Grand Bahama, Eleuthera, and Andros Islands in the Bahamas, where the large-scale wind is southeasterly). When Joanne’s work was performed, such direct observations of cloud fields were not available.

Since computers were available in the early 1970s, EML provided resources to construct a model of the sea breezes. Fortunately, the computer was sufficient to run a three-dimensional model of the sea breezes over south Florida. Using 11-km horizontal grid intervals over a 33 X 36 grid mesh with seven vertical levels, the model just fit on a CDC 6600 computer at the National Meteorological Center [NMC; now called the National Centers for Environmental Prediction (NCEP)]. Given the restraint on access to the computer and its comparative slowness, only one hour of simulation was possible each day. Ten hours of simulated time required ten days!

Dr. Simpson, however, felt strongly that students and research staff should not just be theoretical modelers. They need to also experience real weather. For this reason opportunities were provided for my participation in the Florida Area Cumulus Experiment (FACE; Simpson and Woodley 1975; Biondini et al. 1977; Woodley et al. 1977; see Fig. 2.3 for a caricature I drew during FACE). This experiment involved randomized cumulus cloud seeding (Simpson 1977). As part of Joanne’s mentorship, I flew on several FACE cloud seeding experiments, both with the seeding aircraft and in a separate aircraft that often flew at just a few hundred feet above the ground! I was also permitted (and encouraged) to fly a hurricane Storm Fury flight (into Ginger in 1971). This ability to participate in a variety of research programs was facilitated by the leadership of the government agencies that managed the weather research groups (the National Hurricane Research Lab and EML) and the National Weather Service [National Hurricane Center (NHC)]. These groups were collocated in a single multistory building (Fig. 2.4) with the Department of Atmospheric Sciences at the University of Miami in Coral Gables, Florida. This vertical linkage permitted a free exchange among academic, research, and operational weather communities.

This exposure to operational weather, which was permitted by the perceptive leadership of Joanne’s husband, Dr. Robert H. Simpson, allowed researchers to experience the cold reality of making actual forecasts that affected lives and properties. We were permitted to watch NHC forecasters prepare hurricane watches and warnings, which allowed us to better relate our studies to actual public need.

Joanne is an observational meteorologist, as well as...
a modeler. She provided resources to instrument 10 locations across south Florida with recording surface weather stations. Made by MRI Inc., these stations, which archived data on strip charts, were among the first applications of such portable automated weather stations. Such exposure of a student to real data helps establish a reality check when developing theoretical models. Figure 2.5 illustrates one of these observational platforms. The data from these mechanical weather stations, and from a set of volunteer observers that were recruited for FACE, resulted in several papers (Pielke and Cotton 1977; Pielke and Mahrer 1978). Among the results found was the prominent role of sea-breeze horizontal wind convergence in establishing favorable environments for thunderstorms and their merger. An example of observed and modeled winds across the east-west cross section that contained the MRI sites is displayed in Fig. 2.6. The wind convergence locally increased convective available potential energy (CAPE)
and physically moved cumulus clouds toward each other. As discussed in Simpson et al. (1980), Wescott (1994), and more recently in Simpson et al. (1993), merged cumulus clouds rain much more than the individual clouds would separately. This concept of cumulus cloud merger originated from Joanne’s dynamic cloud seeding hypothesis (Cotton and Pielke 1995) and is an important reason for the high correlation between sea-breeze convergence zones and thunderstorms (Ulanowski and Garstang 1978a,b; Cooper et al. 1982; Pielke et al. 1991; Garstang and Fitzgerald 1999; see also Fig. 2.7).

2. The University of Virginia years

As part of Joanne’s position at the Center for Advanced Studies at the University of Virginia, I was hired as an assistant professor of environmental sciences in 1974. In this capacity, she continued to mentor my research and to aid in the development of an academic program. Among her major efforts was the recruitment of Dr. Ytzhaq Mahrer of the University of Jerusalem in Rehovot. This was a fruitful collaboration that permitted additional developments of the EML sea-breeze model to include topography (Mahrer and Pielke 1975, 1976) and improved computational solution techniques (Mahrer and Pielke 1978). Professor Mike Garstang and I also met during this time period, and developed a close research collaboration (e.g., see Pielke et al. 1987). Joanne was responsible for bringing Mike and I together, where, as an experimentalist and a numerical modeler, we were able to successfully pool our different expertise. This was another example of where Joanne recognized the need for combined observational and modeling studies.

In my role as an assistant professor and later associate professor, I adopted Joanne’s philosophy of serving as a facilitator for student research, rather than a manager. Students who graduate from such a program benefit greatly from this combination of science exposure and collegial interaction. Among the major achievements was one of the first soil–vegetation–atmosphere transfer (SVAT) schemes that formed part of Mike McCumber’s Ph.D. dissertation (McCumber 1980; McCumber and Pielke 1981).

An essential component of Joanne’s leadership ethic was her treatment of support staff. Always requiring excellence, she still treated each person as an individual. They were as much a part of the research team as the scientific staff.

It was during these years that my professional association with Robert Simpson deepened. He was (and is) a source of strength for Joanne and is also an outstanding scientist on his own. I may be the only person who has separately published papers with both Simpsons. This involvement with Bob also resulted in my involvement with both of them in the Typhoon Moderation (TY-MOD) Project, which discussed the possibility of cloud seeding western Pacific typhoons (Simpson et al. 1978).

3. Subsequent years

After I left the University of Virginia, my research continued to be greatly influenced by Joanne’s pioneering work. At Colorado State University, a new modeling system was developed that built on the EML sea-breeze model and the model developed independently by Bill Cotton. This new model was called the Regional...
Fig. 2.6. Time cross section of observed (bottom) and predicted (top) surface winds along an east-west line from Fort Lauderdale, FL, to Naples, FL, along the 18th grid line from the southern edge of the model (from Pielke and Mahler 1978).
My interest in hurricanes was intensified as a result of my collaboration with both Joanne and Bob. Thus it was natural that we would apply RAMS to simulate these tropical cyclones. We chose Hurricane Andrew (1992) since its intensification was underforecast and it made landfall over the same area in southern Dade County, Florida, where I lived while working at EML.

Our explicit modeling of deep thunderstorms in the eyewall and in the spiral bands of a hurricane (using horizontal grid increments of 5 km) was the key to properly simulating intensification of Andrew (Eastman et al. 1996). Such high spatial resolution is needed to accurately evacuate mass from the eyewall region. This was the first simulation of a specific hurricane with explicit microphysics at such fine spatial resolution.

The early observational papers by the Simpsons provided an essential assessment of the credibility of our hurricane model results. Malkus (1958), for example, provides an observed characterization of eyewall–eye dynamics, such as the influence of large-scale environmental shear (Fig. 2.8). In Nicholls and Pielke (1995), we investigated, using RAMS, the importance of wind shear associated with idealized hurricanes. Among our conclusions is that weak vertical wind shear can actually enhance the ability of a hurricane to intensify. Figure 2.9 illustrates the eye and eyewall structure as modeled by RAMS for a mature hurricane (Pielke and Pielke 1997, p. 78). Pielke (1990) used the Robert Simpson decision tree for hurricane development and intensification to illustrate the forecast procedure for these two aspects of tropical cyclones. In Pielke and Pielke (1997) we referred to several early papers by Bob (Simpson 1946; 1954; 1971; Simpson and Riehl 1981) that continue to provide a fundamental basis for prediction research.

On the global scale, the Riehl and Malkus (1958) paper is a major landmark in the study of the energy and water budget of the earth’s atmosphere. The concept

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3 Cotton summarizes the RAMS development and lists a spectrum of papers which resulted from the application of this modeling tool in chapter 8 of this monograph.
of undilute ascent in thunderstorms in the intertropical convergence zone, as one segment in the Hadley circulation, revolutionized the concept of how the atmosphere transfers mass and energy. The Riehl and Malkus study indicated that between 1500 and 5000 active undilute cumulus convective towers (i.e., "hot towers") are all that is needed for the equatorial side of the vertical transport associated with the Hadley circulation. Satellite images that subsequently became available confirmed this hypothesis and illustrate that mass and energy are transported poleward within high upper-tropospheric jet streams, which are referred to as subtropical jets. These jets are an effective mechanism for long-distance rapid communication of weather, a concept referred to as teleconnection.

This fundamental work is the basis for the conclusions of Chase et al. (1996, 2000) that tropical land-use change can alter the patterning of where these hot towers occur. Deforestation results in a drying and warming, such that cumulonimbus convection tends to occur more over nonforested regions and over tropical ocean areas. This pattern shift results in alterations in the teleconnections with higher latitudes, such that weather patterns may be permanently changed. ENSO events, which also affect the patterning of thunderstorms, similarly affect higher latitudes. Pitman and Zhao (2000) and Pitman et al. (1999) confirm the major role of land-use change affecting the Hadley circulation, and higher latitude weather. In one of my numerous fruitful collaborations with Bill Cotton, we published Cotton and Pielke (1995), where we connected our experiences associated with weather modification studies at EML with the current overselling of the ability to predict future climate. Land-use change was one of the issues that we used to illustrate that climate predictability inherently may be more limited than has been traditionally thought.

The role of the hot towers is critical to this human-caused climate sensitivity. Even though the location of the hot towers covers only a relatively small percentage of the earth's surface, large climate change effects can occur! This overlooked climate change issue is built on Joanne's early pioneering work.

4. Conclusions

The richness of Joanne Simpson's research accomplishments are best appreciated by tracking our current knowledge of the atmosphere to where these concepts were first discussed in the peer-reviewed literature. Her breadth of contribution is impressive and ranges from...
the cumulus cloud to global scale. Early in her career, she recognized the critical role of cumulus clouds in the earth’s atmosphere, and now she continues to build on her innovative and broad expertise in such programs as the Tropical Rainfall Measuring Mission (TRMM; Kummerow et al. 1998) and the Tropical Ocean Global Atmosphere Coupled Ocean–Atmosphere Response Experiment (TOGA COARE; Halverson et al. 1999). When one uncovers the origin of many of our most basic concepts in atmospheric science, it is quite impressive how much of this knowledge is founded in her original work!

Finally, while completing pioneering research results, she also recognized the need to mentor the next generation of scientists. Her sacrifices are candidly summarized in Simpson (1973), a publication that was also influential in addressing the prejudices against women in science. Joanne’s publication has sensitized many men to this obstacle.

Joanne’s career has spanned all aspects of our profession, from research and mentorship to teaching and service. Her guidance as American Meteorological Society publication commissioner and scientific and technological activities commissioner and president has effectively led the society to its current very high level of achievement. She was also involved with Robert Simpson in setting up a private company (Simpson Weather Associates), which transfers research knowledge to help solve real-world problems. This responsibility of university professors is not widely recognized, yet this is a prime mechanism that can be used to interface with societal needs.

All the best to Joanne on an extremely valuable career that is still continuing full throttle!

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REFERENCES


