GLOBAL CHANGE AND REGIONAL IMPACTS: WATER AVAILABILITY AND VULNERABILITY OF ECOSYSTEMS AND SOCIETY IN THE SEMIARID NORTHEAST OF BRAZIL


This book focuses on results from a joint German-Brazilian program (Water Availability and Vulnerability of Ecosystems and Society, or WAVES) to assess the socioeconomic impacts that global change will have on northeast Brazil. The WAVES study area of interior northeast Brazil is a semiarid region having a rather short (3–4 month) rainy season (February–May). The annual rainfall in this region averages between 600 and 700 mm. However, there is considerable year-to-year variability, with the annual precipitation for any given year ranging from 10% to about 200% of the long-term average. This large range in precipitation, and how it might change during the first half of the twenty-first century, are important issues addressed in this book.

But water availability is just one factor that must be considered in developing scenarios for the future. Other factors, such as water quality, water demand, geology, farming practices, industrial development, vegetation type, etc., must also be considered by government planners, agriculturalists, and water resource managers when preparing plans for sustainable development in the region.

This book, divided into eight parts, describes the many factors that should be included in developing scenarios for future planning purposes. Part I deals with integrated methods and results, which are presented in three papers that focus on integrated scenarios for two states in Northeast Brazil (Piauí and Ceará), integrated modeling of climate change impacts in Northeastern Brazil, and a GIS-based model for sustainable development and land use. Part 2, covering natural and socioeconomic conditions in Piauí and Ceará, consists of six papers that describe the climate, water resources, physical and environmental features, vegetation, and degradation factors in the two states. Part 3 contains two papers dealing with climate scenarios and climate modeling. Part 4 focuses on water availability, water management, and water use. The eight papers included in this section deal with water management, water quality, sedimentation of reservoirs, hydrological modeling, reservoir yield vulnerability, water resources planning, and an assessment of water costs. Part 5, “Agricultural Productivity and Soils,” consists of three papers dealing with an information system for land resources, effectiveness of fertilization, and seepage and groundwater recharge. Part 6, “Vegetation and Landscape Ecology,” consists of three papers that describe the sustainable use of natural resources, vegetation characteristics in the cerrado and caatinga areas, and climate and desertification in the region. Part 7, “Economic and Socio-cultural Analyses,” has four papers dealing with issues such as quality of life, migration, economic analysis of different farming systems, structure and possible development of the agricultural sector, groundwater supply conditions, and willingness to pay for desalinated water. The last section, part 8, consists of two papers that describe mathematical tools that are useful in visualizing and analyzing the extensive datasets used in the WAVES project.

The book provides useful information concerning the complex multidisciplinary task of developing scenarios that can aid decision makers in formulating plans for sustainable development in an area that is highly vulnerable to climate variability and change. Although the title of the book emphasizes global change and regional impacts, it is evident that coping with natural interannual variability, such as that related to the El Niño–Southern Oscillation cycle, is extremely important in planning for future sustainable development in the region. Other factors that...
influence water supply include water storage capacity, reservoir sedimentation, changing vegetation (due to human activities), ground absorption and runoff, and availability of aquifers. Water quality must also be taken into account when planning for future development in the region. Many places in the interior of northeast Brazil deal with high-salinity water, which is not useful for agriculture or human consumption. Consideration is given to desalination, and whether or not the cost is practical for the region. In addition, many areas do not have treated water, which presents serious health issues for the residents. The cost of water (storage, treatment, and supply) may serve as a limiting factor for development in the region, where profit margins are small for a large part of the population.

Although containing considerable useful information for the study region, the quality of both the English and the contents varies considerably from paper to paper. The nonstandard use of hyphenation at the end of lines (hyphens not placed between syllables) was somewhat distracting to this reader. Also, the format of the book, a collection of individual papers in a single volume, produced considerable redundancy, especially in the introductions of the individual contributions. However, for someone unfamiliar with the semiarid northeast Brazil region, the book provides considerable useful background information.

—Vernon E. Kousky

Vernon E. Kousky is chief of the Development Branch at the NOAA/Climate Prediction Center.

**NEW PUBLICATIONS**

**TORNADOES (REVISED EDITION)**


In this title, the author provides a general overview of current information that shapes the way tornadoes are understood and studied, including discussions of how a tornado begins, what happens inside a tornado, how a tornado travels, and how a tornado dies; explanations of jet streams, squall lines, thunderstorms, supercells, vortices and angular momentum, dust devils, and waterspouts; and a look at when and where tornadoes happen. Organized and written in an easy-to-follow style, and appropriate for middle school and high school students, teachers, and general readers, it is part of Facts On File’s "Dangerous Weather" series.

**WATER: SCIENCE, POLICY, AND MANAGEMENT**


From the local to the global scale, water use and sustainability are issues of historic importance. Never before has water science needed to inform water policy so much, and never before have we seen how challenging it is to advance that relationship. How rapidly is the demand for water growing? What climate- or pollution-imposed limits to water supplies exist, and how can we best manage them? How can science work more closely with the policy and engineering communities to perfect knowledge-based water planning? This book discusses these issues, and more.

**LIVING WITH FLORIDA’S ATLANTIC BEACHES: COASTAL HAZARDS FROM AMELIA ISLAND TO KEY WEST**


Florida’s Atlantic coast has seen much structural development on highly erodible shores periodically hit by powerful storms. Coastal structures are vulnerable to sea level rise, shoreline retreat, winter storms, and hurricanes. Here is a guide to mitigating or reducing losses of property, human life, and natural resources by living with, rather than at, the shore. This title includes an introduction to coastal processes and geology along with a brief history of coastal hazards and shortsighted human responses.
standing of atmospheric processes to my students, then I am all ears.

In teaching introductory meteorology and climatology, I draw the content for my lectures from various textbooks (e.g., Moran and Morgan 1997; Lutgens and Tarbuck 2004). Based on my experience, I find that these—and similar—textbooks follow the same basic pattern. They begin with the origins, composition, and vertical structure of the atmosphere, followed by a discussion of radiation and Earth–Sun relations. Subsequent chapters address temperature, atmospheric humidity, atmospheric pressure, winds (upper air, surface, and global), air masses and fronts, cyclones and anticyclones, thunderstorms and tornadoes, weather forecasting, regional climate, and climate change. For the most part, Ackerman and Knox's textbook follows this lead.

In my opinion, the real difference between the various introductory textbooks lies in how the author(s) present the information, explain the concepts, use examples, provide analogies, etc. Ackerman and Knox do an exceptional job in this respect. In my classroom, I continually emphasize that each chapter lays a foundation for the remainder of the book; the chapters are not independent of one another; and once we complete discussion of a chapter, it does not mean they can forget it, as they will need to draw on those concepts later in the course. Ackerman and Knox emphasize these exact same points. They constantly make connections between chapters, reminding readers of what they have previously learned and how it applies to principles currently being taught.

In addressing the chapters individually, there will undoubtedly be some personal bias in my discussion, as it is only human nature to compare which is new to that which has been used in the past. As with all other introductory texts, Ackerman and Knox begin with a discussion of the origin, structure, and composition of the atmosphere, including a very nice description of the cycling of atmospheric trace gases. But what really stands out in chapter 1 is their introduction to weather maps. As a way to involve my students in the class and (hopefully) arouse their interest in viewing the weather segment of the local newscast, or perhaps The Weather Channel, we start looking at weather maps from day one. Thus, I really appreciated the authors' discussion of weather station models and time zones. However, although pertinent to the presentation of weather maps, I was surprised to find in this chapter the discussions on atmospheric pressure and density (typically a chapter unto itself in comparable textbooks), and watches, warnings, and advisories (typically presented in the chapter on severe weather).

Chapter 2, “The Energy Cycle,” was organized much differently than the introductory texts I am used to—which is not to say it is wrong, just different. For instance, instead of beginning with a discussion of the
A symposium on possible relationships between solar activity and meteorological phenomena had been held at Goddard in November, 1973, and the guest of honor was Charles Greeley Abbott of the Smithsonian Institution. Abbott was 101 years old at the time, and had spent nearly eighty years measuring the solar constant and searching for correlations between solar changes and tropospheric weather. When he began his work at the beginning of the 20th Century few meteorologists or climatologists believed that the weather or climate could be influenced by solar activity. Interest in the subject was and continues to be worldwide and nearly 200 scientists from many countries including England, Japan and the USSR participated in the symposium. As an indication of the broadly interdisciplinary nature of the subject, there were meteorologists, aeronomers, solar and plasma physicists, and astrophysicists in attendance. And yet, with all the interest in the possibility that solar activity actually can influence the weather or climate, as demonstrated by the publication of well over a thousand papers and books on the subject, a large number of respected scientists reject the notion of any connection between the two phenomena. The principal objection has been that no strongly defensible physical mechanisms for linking them together have come to the fore, and moreover, such correlations as have been reported are sometimes localized, often contradictory, and not amenable to verification by independent observations.

The proceedings of this important conference... were published in 1975, a few months after my return from Peru. In its summary, the editors noted that "the symposium addressed itself to three fundamental questions:"

"(1) What is the evidence concerning possible relationships between solar activity and meteorological phenomena?"

"(2) Are there plausible physical mechanisms to explain these relationships?"

wavelengths of the electromagnetic spectrum and Earth–Sun energy relations, chapter 2 begins with a discussion of temperature, temperature scales, heat, and specific heat, concepts that typically fall under the domain of the chapter on temperature. Later in chapter 2, Ackerman and Knox introduce adiabatic cooling and warming. While it certainly falls under the purview of “transferring energy in the atmosphere,” most authors cover this topic as part of their discussion on atmospheric stability. Lastly, surprising omissions from the discussion on solar energy included any mention of frequency (and the relationship between wavelength and frequency) and solar intensity (and its calculation).

Very good explanations and descriptions of diurnal and annual temperature cycles and the factors that drive them comprise chapter 3 (“Temperature”). Also included is an excellent discussion of interannual temperature variations, a topic not usually given much attention in introductory texts. I was, however, disappointed that heating, cooling, and the growing number of degree days were not mentioned. And again, for those used to a chapter devoted to atmospheric stability, you will find it here under the section heading “Temperature Variations with Height.”

Next to solar and terrestrial radiation, my students find the concepts related to atmospheric moisture (chapter 4) the most difficult to grasp. Here, Ackerman and Knox provide good background and present a detailed description of moisture concepts, from which the individual instructor can glean what they choose to present to their class. Personally, I like to demonstrate the relationships between temperature, atmospheric moisture, and relative humidity mathematically. Unfortunately, the authors do not provide tables of saturation mixing ratios nor saturation vapor pressures, only figures that demonstrate temperature–moisture relationships.

Chapter 5, “Observing the Atmosphere,” was a pleasant surprise. Whereas most authors of introductory texts add a section in each chapter describing the instruments used to observe the specific variable, Ackerman and Knox devote part of a unique chapter to it. Their discussion on interpreting satellite and radar images was particularly effective (although Doppler radar images are typically discussed in the thunderstorm and tornado chapter). Very well presented, but (in my opinion) misplaced, was the section on reflection, refraction, and scattering of solar...
“(3) What kinds of critical measurements are needed to further determine the nature of solar/meteorological relationships and/or the mechanisms to explain them and which of these measurements can be accomplished best from space?”

By the time the AGU Spring Meeting took place, Dick Goldberg, although his main interests were in flying rockets to make measurements in the mesosphere, had been given the task of following up on these questions along with some support funds. Over lunch, knowing of my long experience in the effects of solar activity on the ionosphere, he asked if I would be interested in exploring the possibility that such activity might affect the troposphere. Although we would work together on the project the brunt would fall on me because of his other responsibilities.

Our principal aim would be to address the second question, that is, to try and find physical mechanisms that might explain some of the correlations reported over the past hundred years or so, including those by Abbott. However, in order to find physical mechanisms we would have to amass the evidence to address the first question, too. Dick said that he knew nothing of the subject, so in my quarterly reports I should write down everything I had learned during that three-month period.

When I returned home I wrote up a sole source proposal spelling out the work to be done according to our conversation. To estimate the cost I carefully analyzed what my direct costs [were], including labor (how many hours or months would it take for me to complete the work), travel expenses, cost of data and computer costs. Based on my contracts with Bob Stone, NASA allowed an overhead expense of 20% to cover things like company half of social security, hospitalization insurance, telephone, etc. The total cost was approximately fifty thousand dollars, which I submitted along with the work statement. In the meantime I continued my work on the RAE-II data with Bob Stone.

Soon afterwards Dick called me and said, rather ruefully: “Gee, John, I only have thirty thousand dollars in the budget for this work.”

I reflected for only a moment, and then responded: “OK, I’ll do it for that, then.” It wasn’t the first time I had agreed to a lower price, but perhaps I should explain that it was always the work that was important to me, not the money. The money was only to allow my family to live in reasonable comfort, but the research, the science was what it was all about for me. I was a scientist, not a businessman. For this project, involving many trips to Goddard, I was able

radiation. I thought this should have been covered in chapter 2, describing the fates of solar radiation passing through the atmosphere.

Overall, chapters 6 and 7, which discuss winds (“Atmospheric Forces and Wind” and “Global-Scale Winds,” respectively) were nicely presented. The last couple sections of chapter 7, describing seasonal variations of the ITCZ and the monsoon, and especially the first half of chapter 8, describing atmosphere–ocean interactions and ENSO, will help strengthen the lecture content for my regional climatology course. The first half of chapter 8 provides an excellent discussion of the horizontal and vertical distribution of ocean temperatures, ocean currents, Ekman transport/spiral, and upwelling. The second half of chapter 8 offers an interesting discussion of tropical cyclones. Chapter 9 covers air masses and fronts in a typical manner.

As a backdrop for their presentation of “Extratropical Cyclones and Anticyclones” (chapter 10), Ackerman and Knox used a case-study approach of the storm that sunk the Edmund Fitzgerald to describe the life cycle of an extratropical cyclone. Using this exceptionally effective method, they describe for the reader how a cyclone is "born," how and why it grows (or doesn’t) into a mature storm, and how it “dies.” A very interesting approach!

Chapters 11 (“Thunderstorms and Tornadoes”) and 12 (“Small-Scale Winds”) cover all of the respective aspects one would expect to be discussed in these chapters. Although I am not in the forecasting field, I found chapter 13 particularly interesting. Ackerman and Knox give a splendid history of weather forecasting, from the early use of local folklore, to persistence and climatology, to the use of trends and analogs. The authors again use a case-study approach to effectively demonstrate how three teams of meteorologists used the various forecasting methods available at that time to develop perhaps the most important forecast of our time, thus choosing the date for the D-Day invasion. Finally, the authors present a very interesting look at the history of numerical modeling, from the conception of L.F. Richardson’s work to a discussion of the various models, including a description of how numerical model analysis helped forecasters predict 1993’s “Storm of the Century.”

The final chapter covers “Past and Present Climates.” I often take the introductory material (e.g., climate controls) for my regional climatology class
to minimize my travel expenses through the kind benevolence of my high school friend, Richard Hott. He had left the Paw Paw area and was living in Silver Spring, Maryland, a short commute from the Space Center. He and his wife Jackie provided room and board for all of my visits, and I had to bill NASA only for air fare and ground transportation.

My first task was to search the literature and amass the reported evidence of connections between weather; climate and solar activity. I dutifully wrote down everything I had surveyed in my first quarterly report, about 150 pages of single-space type and dozens of graphs and illustrations. When it was disseminated by NASA I began to learn how controversial the subject was. A.B. (Barrie) Pittock, a Principal Research Scientist with the CSIRO Division of Atmospheric Physics in Mordialloc, Australia, was a visiting scientist at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. He wrote a completely negative review article of the whole subject in 1977. In it, he rebutted many of the specific correlations I had written about, but he did not reference my report. I strongly suspected that he was at least aware of it because NCAR was on the NASA distribution list, and one of the points in my report that he took pains to rebut was a highly positive correlation between sunspots and Siberian thunderstorms published by Septer in 1926. It was doubly curious that his review was so vitriolic, since one of the strongest proponents of solar activity effects on weather, Walter Orr Roberts, was located at NCAR at the time. Pittock's position as stated in the review article was clear: "... it seems that despite a massive literature on the subject, there is at present little or no convincing evidence of statistically significant or practically useful correlations between sunspot cycles and the weather or climate."

At the end of the year, I had a stack of reports about four inches high, covering all aspects of the subject, including solar physics, atmospheric electricity, atmospheric chemistry, cosmic ray physics, solar wind interactions with the magnetosphere, as well as all the reported correlations of temperature, rainfall, thunderstorm activity, etc., with solar observables like sunspots, flares, coronal holes, sector boundaries, and magnetic activity, which is itself correlated with solar variables.

[...]

It was during this period that we had begun our search for physical mechanisms. One promising from textbooks such as this. While the authors provide good analogies with which the readers can identify (including climates having different "personalities," much like people), I was disappointed that the world map of Köppen climate classifications was reduced to less than a half page (much of the detail was lost), and that no table was provided that quantifies how Köppen classified climates.

Overall, I found this textbook particularly strong in four aspects: 1) how well the authors present the information and explain the concepts; 2) the effective incorporation of analogies and examples, such as historical events impacted by weather (e.g., the wreck of the Edmund Fitzgerald, development of the D-Day forecast, the influence of extreme temperatures on Napoleon's and Hitler's invading forces, etc.), which help the reader connect the importance of weather to life (or death); 3) very interesting sidebars (or boxes) in each chapter that help answer questions students often ask, or point out facts that the reader may never have known (e.g., "Moist Air is Lighter Than Dry Air," "Why Do Your Ears Pop?,” “Atmospheric Moisture and Your Health,” “Down the Drain with the Rossby Number—Clockwise or Counterclockwise?"); and, 4) a companion Web site that is both interesting and useful (for both students and instructors).

While this textbook is very good, it is still my plan to blend my lecture content from a variety of sources. All introductory textbooks have something to offer: a unique way of viewing or presenting a concept, a figure or table that is particularly effective, examples that can be used in the classroom, etc. I suggest taking what works best for the individual instructor from the different source textbooks and tailoring that information to one’s lecture. Suffice it to say, I will incorporate much of the Ackerman and Knox text into my lectures.

—STEVEN J. MEYER

Steven J. Meyer is an assistant professor of earth sciences in the Natural and Applied Sciences unit at the University of Wisconsin—Green Bay.

REFERENCES


avenue lay in the response of atmospheric electrical quantities (e.g., potential gradient, air–Earth current density) and thunderstorm activity to solar flares as reported by a number of researchers. Along these lines we formulated a theory based on the long-term inverse relationship between sunspot cycle and cosmic ray intensity, the latter of which may alter the atmospheric electrical characteristics and promote the electrification of clouds. We initially described our theory in a NASA Technical Report, and then submitted an abstract to report our results at the upcoming AGU Meeting in San Francisco in December, 1976.

During one of the sessions I had run into Hans Dolezalek. . . . The evening before I was scheduled to speak we had dinner together; along with Ralph Markson, another atmospheric electrician. Hans wanted to hear the details of my upcoming talk, so I gave him a copy of our technical report. The next morning he was in the audience, and immediately after the session chairman called for comments and questions, Hans jumped up to criticize my paper: I immediately felt that I had been sandbagged because he had obviously read our report very carefully the night before. However, in his criticism he confused our factor of air conductivity with air resistivity, which are reciprocals of one another. A change in value of the one would increase the atmospheric electric potential, which we had argued; but he mistakenly argued that it (the potential) would be decreased, making our theory untenable.

In spite of Dolezalek’s objection, our paper raised quite a stir, and Robert C. Cowan, science editor of the Christian Science Monitor in Boston, published a front-page article about it in his December 28, 1976 issue. A week or two after the article appeared Mr. Cowan called me from Boston. A Mr. Dolezalek from the Office of Naval Research (ONR) had telephoned him and demanded that the paper print a correction to the article, and explain to its reading public that the theory by Herman and Goldberg was completely wrong. As an atmospheric electrical expert and actually a world leader in that scientific discipline he apparently felt compelled to try and suppress any new ideas that might conflict with established views on the subject Mr. Cowan declined to publish a retraction, and politely dismissed Mr. Dolezalek.

Ralph Markson . . . further pursued the electrical connection between solar flare eruptions and thunderstorm occurrence. We, too, continued to refine our theory while at the same time investigating other possible physical mechanisms such as changes in the latitudinal gradient of atmospheric pressure brought on by solar energy inputs to high latitude locations during winter time. We discussed our refinement at the December, 1977, AGU Meeting, and then published it in the Journal of Atmospheric and Terrestrial Physics in 1978 . . . .

Two years later at an atmospheric electricity conference being held at the University of Manchester Institute for Space Technology (UMIST), in Manchester, England, Dolezalek apparently felt that he had been too harsh in his earlier criticisms of my research. He was chairing a session, and in his introduction he talked about many of the advances being made in the field. He pointed up into the audience at me and said, in effect, “And we must not forget the electrical effects of Antarctic blizzards that John Herman who is here today discovered in the early 1960s.” I appreciated his magnanimity in mentioning that work.

Robert C. Cowan published another front-page article about the electrical connection in the June 7, 1978 issue of the Christian Science Monitor. He gave Markson’s new work prominent coverage, and mentioned our prior work of “. . . a couple of years ago.” This time he did not receive any telephone calls from Dolezalek, but it may or may not be significant that ONR was now funding Markson’s research.

At the end of the first year Goldberg, in spite of growing opposition to our work, was able to find additional funding so that we could address the third question posed by the Abbott Symposium. That is, what kinds of critical measurements could be made to further determine the nature of the relationships and/or their causal physical mechanisms, and which might best be accomplished from space? In seeking answers to this one I went back through my four-inch stack of reports, rereading and restudying the information I had compiled the first year. After spending several months of review I wrote still another report suggesting a number of experiments, observations and critical measurements that should be conducted to further clarify the issues.

While doing this it suddenly struck me that I had collected and analyzed enough data to write a book. I took the quarterly reports apart, rearranged the information into coherent chapters and rewrote large sections. I then submitted the manuscript to NASA for permission to approach a commercial publisher; but they liked it so well they decided they would publish it themselves. However, since Goldberg had collaborated with me on the work it was decided that he should be co-author of the book.
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