HISTORICAL RESEARCH IN THE ATMOSPHERIC SCIENCES

The Value of Literature Reviews, Libraries, and Librarians

BY DAVID M. SCHULTZ

Despite growing access to electronic information, written reviews of scientific literature not only remain helpful in guiding the future of atmospheric science, but they also reveal the continuing value of our libraries and librarians.

This paper originated from a talk given at the sixth annual meeting of the Atmospheric Science Librarians International, at the 2003 American Meteorological Society (AMS) annual meeting, on 13 February 2003. Because one of the themes of the meeting was the history of the atmospheric sciences, I was asked to give a talk about doing research on the history of science through reviews of the scientific literature. The talk ended up showing the contribution that reference librarians can make to scientists, especially those scientists doing literature reviews. I am more a scientist than a historian of science, but as this paper shows, my research has taken me into some interesting aspects of historical research in order to understand and interpret my scientific interests.

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Scientific literature reviews are a way to distill the essence of a specific research topic into a piece of literature. In the distant past, summaries of the literature consisted of bibliographies, or lists of relevant papers on a particular topic with a short summary of their findings (e.g., Goodman 2003). The first, if not most significant, collection of scientific review articles in meteorology was the *Compendium of Meteorology* (Malone 1951). The stated purpose of the *Compendium* was "to take stock of the present position of meteorology, to summarize and appraise the knowledge that untiring research has been able to wrest from nature during past years, and to indicate the avenues of further study and research that need to be explored in order to extend the frontiers of our knowledge" (Malone 1951, p. v). *Reviews of Geophysics,* a journal that would occasionally feature articles on atmospheric science, was founded in the 1960s. The recent trend in the number of review articles is upward, fueled by the number of tribute symposia at the AMS annual meetings (e.g., the 2000 Fujita Symposium, documented in the January 2001 *BAMS*).

Literature reviews are the scientific equivalent of a box set of music. More than just a greatest hits package, or a recitation of relevant articles that pay lip service to their authors, literature reviews serve a number of purposes. Well-written, well-researched literature reviews are a piece of scientific scholarship that can present an overview of an entire discipline in a bite-sized chunk of reading. They can also provide a sense of history to the reader, exploring how concepts originated and evolved. Literature reviews can promote little-known ideas, which are nonetheless intriguing, underappreciated, and even worthy of reexamination and possible reintroduction. Good literature reviews interpret, extend, and integrate the existing literature, a kind of meta-analysis of the preexisting studies. Literature reviews can be valuable to academic faculty because references are organized in one place, benefiting lecture preparation. Students also benefit from literature reviews, which can serve as study guides or supplementary reading on topics for which textbooks may not be written or up to date. Finally, literature reviews can illuminate viable research horizons for future studies.

Because the scientific literature is one vehicle by which science progresses, I stress to my students and colleagues the importance of reading and understanding the previous scientific literature on a topic. Relating new research to the previous literature is an important component to any research problem. Also, literature reviews are a way to learn about the history of science, without being a historian. Because of the increasingly electronic availability of information, however, the way scientists access and use this previous literature is changing. This is forcing a change in the relationship between scientists and librarians. Librarians can play an integral role in science, by not only assisting scientists to locate relevant materials, but, by being knowledgeable in meteorology and actively participating in the research process.

In the relatively short time I have been a scientist, I have experienced what I will term three phases in my exploration of the scientific literature and my relationship with librarians. For the purposes of this paper, I refer to them as phase 1: doing it yourself, phase 2: librarian-assisted searches, and phase 3: the librarian as a collaborator. Whereas these phases relate to my experiences, others may have encountered similar phases, although experienced them in different orders.

PHASE 1: DOING IT YOURSELF. The do-it-yourself phase lasted throughout my graduate student days (1988–96). This was an era before electronic access to databases was readily available. The old-fashioned system of interlibrary loan was unfortunately slow, taking as long as months. Due to space constraints in the library at my graduate school, less commonly used journals were first warehoused, then eventually disposed of. One particular journal that suffered this fate was *Geofysiske Publikasjoner,* the Norwegian journal that published many of the pioneering meteorology articles in the early twentieth century.

In this type of environment, graduate students generally had to fend for themselves if they wanted to pursue research that extended beyond the readily available literature. I started with a few basic papers and followed every relevant reference in the bibliographies. I manually looked through years of hardbound copies of *Meteorological and Geophysical Abstracts.* Interviews with scientists took me down other paths, too. Fortunately, most of the articles of which I was in search were available in the libraries to which I had ready access. I do not recall using reference librarians much, if at all, during this time.

An example of the type of research I conducted in this environment was on the history of the occluded front. Occluded fronts result from the maturation of a low pressure system when the cold front is purported to catch up to the warm front. The concept was developed (I hesitate to use the term discovered) by Norwegian meteorologists Bjerknes, Solberg, and Bergeron in 1920s. Because I was a naïve first-year graduate student, I had little prior experience with these concepts, so it was logical that my first task was a thorough literature review to see what had been published previously. I started from a small set of articles that my advisor had previously identified. Despite its 70-yr history, the occlusion process had not been thoroughly examined in the scientific literature, although many papers had hinted at problems with the Norwegian occlusion model. The result of this research into the scientific literature was my M.S. thesis, which was published as Schultz and Mass (1993). Although the majority of that paper consisted of a case study of a well-defined occluded front, section 2 of that paper consisted of a detailed literature review on occlusions.

The extensive historical literature review I had performed paid off in another way. By collecting all of the cases of occluded fronts in the literature, it was possible to use this miniclimatology to evaluate one of the tenets of the Norwegian model. Occluded fronts were initially hypothesized to be one of two types, depending on the thermal structure: cold- or warm-type occlusions (Fig. 1). Cold-type occlusions were hypothesized to occur if the cold air ahead of the warm front was warmer than the cold air behind the cold front (Fig. 1). Thus, the warm front would be lifted by the cold front during the occlusion process. Warm-type occlusions were the opposite, with the cold front being lifted by the warm front (Fig. 1). As a result of my literature review, 21 previous case studies of occluded fronts were collected. Schultz and Mass (1993) noted that the observed thermal structure of these 21 cases did not correspond well to that predicted by the Norwegian model. In fact, no well-documented cases of cold-type occlusions were observed in the literature, although nearly half of the events had the appropriate temperatures that would produce this structure if the Norwegians were correct. [Stoelinga et al. (2002) have since provided an elegant explanation for the differences between cold- and warm-type occlusions based on static stability differences within the frontal zones.] Schultz and Mass's (1993) conclusion of the inadequacy of the thermal structure hypothesis for occluded-front formation was strengthened as a result of the meta-analysis of the previous literature collected during the initial review.

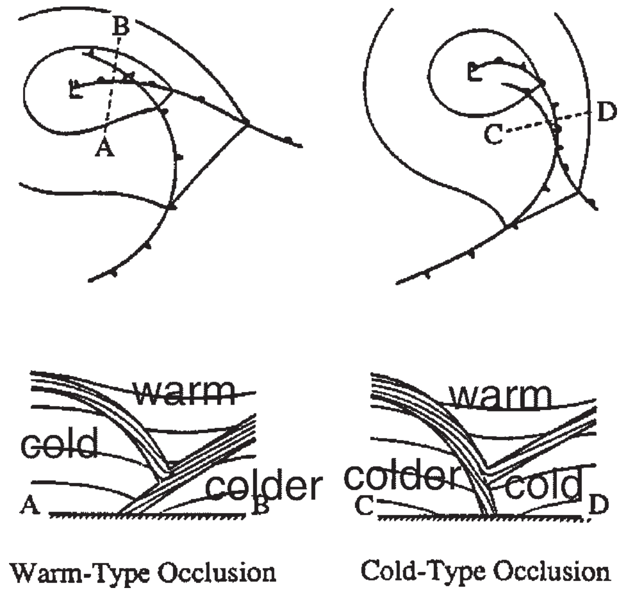

Fig. 1. Vertical cross sections and surface maps through warm- and cold-type occlusions. Cross sections A–B and C–D display potential temperature and frontal boundaries. Adapted from Saucier (1955) and Schultz and Mass (1993, their Fig. 2).

PHASE 2: LIBRARIAN-ASSISTED SEARCHES.

After graduation (1996), I became a postdoctoral research fellow, and eventually a staff member at a federal research laboratory. I found that the libraries and librarians were much more helpful than the ones from graduate school. Perhaps this improvement in service was due to the decreased number of people the library served. This period also heralded greater availability of electronic searches. An example of the type of work that I was able to perform under this environment was a review of the concept of conditional symmetric instability (CSI) entitled "The use and misuse of conditional symmetric instability" (Schultz and Schumacher 1999).

The release of CSI through slantwise convection is believed to be one mechanism responsible for mesoscale precipitation bands. I became interested in pursuing research on CSI because I had read some articles and attended some conference presentations where I knew the concept was used incorrectly, but did not have the experience to know to what extent it was being used incorrectly. One way to clarify this issue was to do a literature review of CSI to learn more. I worked with Katherine Day, a reference librarian at the National Oceanic and Atmospheric Administration (NOAA) library in Boulder, Colorado, to obtain a complete list of previously published papers on CSI. Between my own research and her searches, we found over 250 papers on the subject.

One of the things that interested me about this research was the extent to which the concept of CSI was accepted by the meteorological community over time. When research meteorology took a focused interest in mesoscale processes in the early 1980s, CSI was believed to be one of the principal processes operating on that scale. As a result, CSI was one of the "hot" research topics in the 1980s and early 1990s. Although operational utility was not immediately obvious, eventually CSI was being attributed to nearly every poorly forecasted, banded precipitation event. Emanuel (1990) opined, "To those of us involved in these studies, it seemed for a time that slantwise convection is to mesoscale precipitation bands what baroclinic instability is to cyclones. At the peak of our enthusiasm, however, more sober-minded individuals started to point out some discrepancies." Figure 2, a graph of the number of formal publications related to CSI as a function of time, indicates exactly this point. Initially, the amount of theoretical work on CSI increased through the early 1980s, with the growth in the number of observational studies starting later, in the late 1980s. Eventually, from the early to mid-1990s, researchers and forecasters reached what might be called saturation, possibly due to the overuse and abuse of the CSI concept as Emanuel (1990) had suggested. Shortly thereafter, people became disillusioned with CSI in the mid- to late 1990s and the number of publications thereon began to decline.

Katherine Day helped identify and locate these articles so that an accurate assessment of the community's interest could be determined. Her help was acknowledged in the caption to Fig. 2: "Listings of

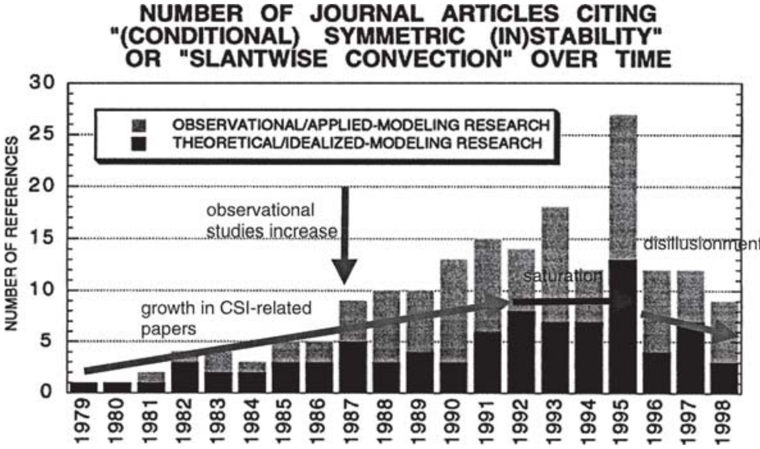

Fig. 2. Number of formal publications that cite atmospheric (conditional) symmetric (in)stability or slantwise convection as a function of time. Articles are classified subjectively as to whether they are more observational and/or applied modeling (light shading) or more theoretical and/or idealized modeling (dark shading) studies. References were compiled through Oct 1998. Listings of articles were compiled mainly from literature searches performed by Katherine Day. Adapted from Schultz and Schumacher (1999, their Fig. 1).

articles were compiled mainly from literature searches performed by Katherine Day."

Schultz and Schumacher's (1999) literature review showed the misuse and overuse of CSI. The research also showed good concepts regarding CSI that were apparently lost could be resurrected and reintroduced in a review paper. In our paper, I made an effort to call attention to what I felt was underappreciated research. One example was Xu (1992), who used simulations of fronts to show the effect that reducing the symmetric stability could have on whether a single precipitation band or multiple bands would form. I felt that this paper demonstrated one possible scenario for interpreting observed cases of single and multiple banding. As a result, I believe the number of citations in recent papers for Xu (1992) has been increasing since 1999.

Finally, Schultz and Schumacher (1999) concluded with suggested directions for future observational, theoretical, and diagnostic investigation. Already, some studies have taken their motivation from our paper. For example, Schultz and Schumacher (1999, 2727–2728) advocated greater integration between observational and theoretical studies on the nature of banding. Recently, Novak et al. (2002) performed a radar climatology for banded and nonbanded precipitation in the northeast United States, comparing their observations to previous theoretical arguments. Part of the inspiration for this work came from reading Schultz and Schumacher (1999) (D. Novak 2003, personal communication).

PHASE 3: THE LIBRARIAN AS COLLABORATOR. Concerned by some recommendations we made in Schultz and Schumacher (1999), Sherwood (2000) questioned the terminology for instabilities that meteorologists commonly use. In preparing our response to Sherwood (2000), I became curious as to the origin of the terms conditional instability, convective instability, and potential instability. A related issue was why two terms existed for the same thing (convective instability and potential instability). I entered my request on the NOAA library Web page, eventually working with Katherine Day again.

The subsequent search took us back to scientific literature from the 1930s, and eventually the 1860s, from England, France, Germany, and India.[1] Katherine Day had the most immediate access to these articles—both the ones already in the library's collection and the ones received through interlibrary loan arriving in Boulder. She would read the relevant sections of the papers and forward me important citations. Such an approach was very efficient to making progress. At times, we were both moving down parallel paths, sharing results via e-mail and phone.

The result of this research revealed the origin of these terms. Specifically, convective instability was an American term coined by Rossby (1932), whereas potential instability was a British term coined by Hewson (1937). The trick to unraveling this puzzle was found in association with Normand (1938). As was the custom at the time, papers presented at the Royal Meteorological Society and published in the *Quarterly Journal of the Royal Meteorological Society* were subject to discussion, which was published as an accompaniment to the article. The comments by Hewson following Normand's (1938) paper revealed the American–British rivalry over the terminology. Such discussion had not been widely known among our colleagues, so our review rediscovered these

[1] Since the publication of our response to Sherwood (2000), I found McDonald's (1963) article in *BAMS*, which had reviewed early developments in the theory of the saturated adiabatic process, although not discussing the origin of the terminology per se.

issues.[2] Schultz et al. (2000) bore the acknowledgment: "Katherine Day (NOAA Library, Boulder, CO) performed an extensive literature survey on the early history of moist instability and its terminology." Such an acknowledgment shows that researchers can benefit from a research librarian who is knowledgeable in meteorology.

LESSONS. These experiences offer a variety of lessons. First, scientific literature reviews are a viable and valuable way to investigate the past and advance science. Second, serendipitous discoveries often happen while browsing journals. Sometimes I discover a different, but equally crucial, article in the same journal adjacent to the original article that I am looking up. This indicates the importance of browsing volumes on the shelves, because one can never know the relevance of adjacent articles in the same volume. I hope that libraries can continue to make every effort to keep the original bound copies of the journals available for use, rather than warehousing them, assuring their nonuse (and perhaps their eventual destruction). Third, tools for assisting scientists in searching the scientific literature are improving at a dramatic rate. Such tools include the World Wide Web, electronic database searches, and online document delivery. This evolution is profoundly altering the relationship between scientists and librarians. Fourth, there is a wonderful feeling of comraderie between the scientist and the librarian while on the trail of historical literature. Finally, good librarians are a tremendous resource. Be sure to appreciate their important work to our community.

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[2] In the review of this paper, D. Keyser (2003, personal communication) noted that the Air Weather Service Manual on the skew *T*–log*p* diagram (1969, 5–26) briefly discussed the Rossby–Hewson debate over terminology.